POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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THE MARCH *of* PROGRESS

high pressure steam from the new Mercury-Vapor Steam plant to the General Electric Co. works at Schenectady. This line is solidly welded throughout and possesses many other unique features, all of which are described in the article by Mr. Rogers.

THREE THOUSAND years ago camel caravans crossed the deserts of ancient Palestine and Syria laden with precious cargoes, spices, frankincense, rare oils — bound for famous ports along the Mediterranean. Today, the camel caravans still follow the ancient trails and to the casual observer, the passage of thirty centuries has wrought little change in the landscape. The desert looks very much as it did in the days of Solomon; the camels pursue their same slow pace through the sand and dust and their drivers live and think in ways not greatly different than did their forefathers at the time Carthage was founded. But there has been a change; the march of progress has extended even into the desert and today the camel faces competition from a strange new type of carrier, a carrier less picturesque perhaps but one infinitely more effective. For the new oil pipe line shown in the foreground in the photograph above will transport 30 million barrels of oil annually. This pipe line, 1180 miles in length, fabricated by the electric arc, is being laid through the ancient lands of Iraq (formerly called Mesopotamia) Palestine and Syria. It taps the rich oil fields near the Tigris and Euphrates rivers and extends to Haifa a port in Palestine and to Tripoli in Syria. The welding is being done to a considerable extent by American welding operators and with American products, Lincoln Electric welding equipment being used.

Speaking of welding, in this issue we present another extremely interesting electric welding job, that described on page 422. Imagine, if you can, a 14-in. steam pipe line less than a mile long which expands 30 ft. from hot to cold and which if it were uncovered would radiate as heat, the entire output of a 20,000-kw. plant: Well, if you find difficulty in exercising your imagination to that extent, read this article, for these startling facts are actually true of the steam line transporting

Readers who were impressed by the series of articles on Extraction Heaters in the Power Plant by Gustav A. Gaffert in our April and August numbers will be pleased to see another article by Mr. Gaffert in this issue. This time he discusses the question of gage board design in power stations. Simple as the design of a gage board may seem, practically nothing has been written on this subject and the lack of knowledge in this respect is only too evident from the many atrocious designs existing in many plants today. Apparently the design of a gage board is one of those things in the design of a station which is usually left to the last and then done in a haphazard manner. Mr. Gaffert's experience in this work with one of the leading consulting engineering firms in this country eminently qualifies him to discuss this subject in these pages, and those of you who have repeatedly dislocated vertebrae in trying to read or manipulate gadgets installed in inaccessible places on improperly designed gage boards will find much in his article on page 418 to agree with.

Do you remember the open field switch discussion which ran in our Readers Conference Department some time ago? We thought it was pretty well settled and that there was little more to say on the subject until E. H. Stivender submitted the discussion which appears in this issue. Mr. Stivender, as you all know, is a frequent contributor to these pages; his series of articles on Relay systems for automatic hydroelectric station control and on the Parallel Operation of A. C. Generators were unusually good and indicated his ability as an analyist of complex electrical phenomena. In this issue Mr. Stivender applies his analytical powers to a solution of the field switch problem and discusses the subject in his customary thorough manner. The opening of a field switch in itself a simple event apparently induces complex effects in the electrical system which are not easily understood without resorting to vector analysis.

WITH THE EDITORS

Electrical Energy

IT IS ENCOURAGING to note the increased use made of electric power consumption records as a business barometer. Variations in the business cycle are somewhat smoothed out due to the damping effect of domestic and to a certain extent commercial power consumption, yet it is the industrial power consumption which really determines the load.

Steel and iron, long an accepted business barometer, have certain inherent disadvantages for this purpose. Being a raw product there is a considerable time lag between the time it leaves the mill and the time it actually enters the commercial retail arena. Either the various manufacturers anticipate a retail demand and order for stock or there is a retail demand which travelling back to the wholesaler and raw material manufacturer is reflected back to the retailer. Either process means that the actual business cycle is out of step with the steel barometer.

Electric power on the other hand reflects instantly business conditions in all lines of business at any instant. Electricity cannot be purchased and stored. It must be used as purchased and therefore gives a true picture of business conditions of the country as a whole.

Accurate statistics are available three or four days after the end of the week in practically all weekly papers, not only for the country as a whole but for different geographical regions. For instance, for the week ending September 9, the country as a whole showed a gain of 11.1 per cent over 1932 as compared to a gain of 11.8 per cent for the preceding week.

This gives no indications of conditions in different territories and further analysis shows that although New England showed a drop of 2 per cent for the week, the West central section showed a gain of 1.8 per cent and the Rocky Mountain section a gain of 3.6 per cent. Undoubtedly as time goes on this index of business will be more widely used and with proper application will undoubtedly be the most accurate reflection of business conditions ever used.

Welding

WELDING has been and is being widely used in industrial service although many are still skeptical of its reliability and ruggedness in service. Examples of good performance are numerous and some are unusually striking. For instance, a remarkable exhibition of welded piping performance was recently noted in connection with the California earthquake.

The City of Long Beach has an installed underground water system about 650 miles long. The system, laid over a period of years, has numerous type joints together with about 250 miles of pipe oxy-acetylene welded with high test steel welding rod. During the earthquake none of these joints failed although there were somewhat over 200 major breaks in other parts of the system.

It is reported that screwed joints were pulled apart, some stripping the threads and others splitting the collars. Earth movements in some places caused offsets in the pipe of 2 to 4 ft. In other places ends of the pipe were jammed together with such force that they cut into each other as deep as 2 in., while in other places the movement corrugated the pipe as far back as 6 in.

Such terrific tests are seldom made and the creditable performance made by the welded joints cannot be overlooked by those contemplating piping installations or replacements.

Going Up in the World

FEW CONVENIENCES in our modern world are taken more for granted than the passenger elevator, yet few would be more indispensable. For some reason we seem more interested in developments in horizontal than in vertical transportation and while every increment in horizontal speed and transportation, however small, gains front page newspaper space, it is only seldom that even a substantial increase in vertical speel travel earns any attention whatever. This probably is due partly to the fact that vertical transportation as exemplified by the passenger elevator is less spectacular, less noisy and less nerve racking than most forms of horizontal travel.

The modern high speed electric elevator is one of the most marvelously developed systems of transportation, highly efficient, highly effective, and unbelievably safe. Consider, for example, the new elevator installation at the Rockefeller Center in New York City, with 24 of the 75 elevators in the main building operating at 1200 ft. per min! During the performance tests some of these cars were run at 1500 ft. per min. and one car has been tested and approved by city inspectors to operate at 1400 ft. per min. Imagine it—over a quarter of a mile per minute, straight upward! In itself this is an unusual accomplishment but what is even more important is that this terrific speed is attained without the slightest discomfort to the passengers and without danger, in fact, these elevators are probably the safest in the world as well as the fastest. The highest rise cars with a travel of some 770 ft. make a round trip with terminal stops only in 95 sec. They are supported by six 11/16 in. cables, some 1600 ft. in length, and are capable of carrying a load of 3500 lb. The total suspended load is 25,530 lb.

It is not our purpose here to describe this elevator installation but the performance is so unusual that we take pride in presenting these figures to our readers, many of whom we know are in charge of elevator equipment. It is true the modern elevator is highly foolproof and things do not often go wrong but like any other complex device, once in a while something does happen and then usually it is the chief engineer who is first called upon to "fix" it. Indeed, he usually is the only one who really "operates" elevators today for the so-called elevator operators in the modern elevator are nothing more than closers of doors, and even these are closed electrically.

POWER PLANT ENGINEERING October 1933

STEAM *for making* GAS

New Boiler Plant at the Elizabethtown Consolidated Gas Co. at Elizabeth, N. J., is good example of power plant practice in the manufacture of Gas

OPERATORS OF STEAM power plants and those connected generally with the electric power industry, ordinarily do not give much thought to the gas industry except perhaps when they are concerned with the operation of gas engines. And yet, gas is an extremely important factor in our modern civilization, one which contributes greatly to our comfort and convenience. One has only to go to the woods for a few weeks, on a vacation, and put up with the delightful inconvenience of trying to cook things over a wood fire or oil stove to appreciate the marvelous cleanliness, simplicity and effectiveness of the modern gas range.

Not only in the kitchen, but in industry, gas is undoubtedly the best form of fuel. True, for certain heat treating applications, electric heating is better, but in the main, gas is still the best known form of fuel for all purposes in industry. It is easily made and transported. A wide range of temperatures is readily obtained and maintained with it. Heat can be applied just as required to any definite part of a process with definite intensity varying from the softest to the most intense flame. Oxidizing or reducing conditions can be brought into play at will. As soon as the demand for heat ceases, the fuel supply is shut off; there is no waste.

In view of this importance of gas, it may be of interest in this article to describe the new boiler plant of the Elizabethtown Consolidated Gas Co. at Elizabeth, N. J., which has recently been completed. While there is perhaps nothing unusual in the design of this plant it represents good practice and will serve to indicate the type of steam plant suitable for the gas industry. Aside from the use of steam for operating compressors and pumps in a gas manufacturing plant, a large amount of steam is used directly in the manufacture of water gas. This gas, as is probably known to most readers, is obtained by passing steam through a bed of incandescent coal usually at a temperature of around 1800 deg. F. The steam is decomposed, its oxygen combining with the carbon, forming carbon monoxide and a small amount of carbon dioxide and liberating hydrogen. Simply stated the reaction is $C + H_2O = CO + H_2$, although actually the process is more complicated by the formation of CO_2 and its subsequent splitting up as it comes in contact with more carbon.

It is evident therefore that steam is a necessary commodity in gas manufacture, and at the Elizabethtown plant this is now produced in a thoroughly up-to-date boiler plant.

This boiler house replaces an old plant which had seen many years service and which through the development of more efficient boiler equipment had become obsolete, though there were certain pieces of equipment in it which were comparatively new and these, upon the construction of the new plant, were retained and moved to the new building.

The building itself is a thoroughly modern structure of brick and steel, amply lighted by large windows set in steel sash and with a roof of Johns-Manville Transite.

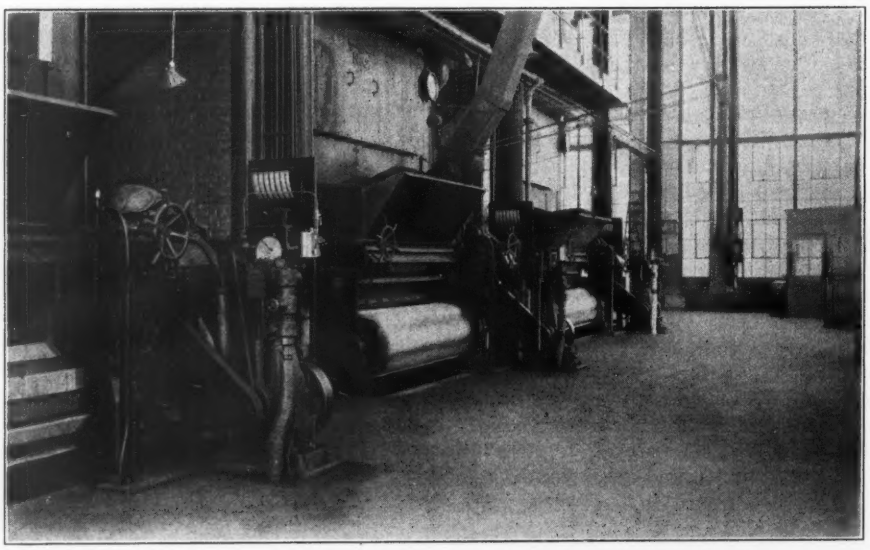


FIG. 1.

Ample space and an abundance of light makes for efficient operation and effective maintenance in the new boiler plant.

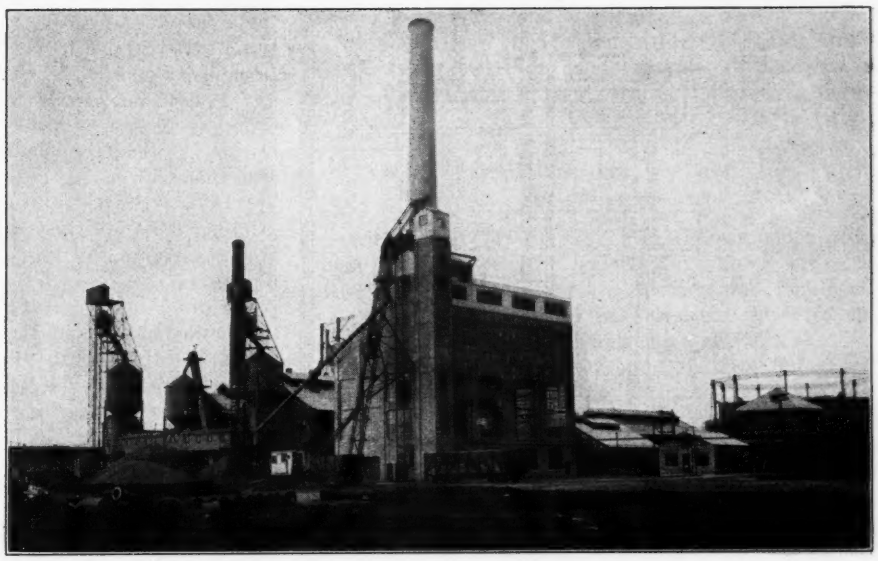


FIG. 2.

An exterior view of the new boiler house showing the skip hoist used in coal handling.

Three boilers are installed, two new B & W units and one old unit of the same make which was transferred from the old boiler plant. There is room, however, for a fourth boiler which is now being installed. This is a 500 hp. unit together with a Harrington Stoker, American Arch, Brooke control, in fact, a duplicate of the first two units installed. In case this proves insufficient, the building itself was designed so that it can be extended to take care of still more boiler capacity, in fact, the ultimate layout provides for a total of 6 boilers as shown in the accompanying plan.

The boilers are straight tube, water tube, longitudinal drum units, rated at 500 hp., built for operation at 200 lb. gage and fired by Harrington chain grate stokers 8 ft. 4 in. wide by 13 ft. 2½ in. long with multiple wind boxes. The latter are normally motor driven but are provided with a steam engine auxiliary. The Deihl motors drive the stokers through Reeves reducing gears while the engines use an enclosed chain drive. The old unit was originally of 400 hp. capacity but when it was installed in the new plant additional tubes were added to bring the rating up to that of the new boilers. A radial brick stack 225 ft. high is supported on a separate foundation adjacent to the boiler house at the approximate center of the ultimate layout. This stack is good for 2500 hp., so it will serve the ultimate capacity of the plant.

Throughout the entire plant, the idea of future expansion has been kept in mind. The present coal handling system for instance while entirely adequate for the three boilers now installed and the fourth being added is so designed that it may be converted into a system capable of handling the coal for six boilers. At present this consists of a track hopper, skip hoist and a weigh larry together with a small storage bunker.

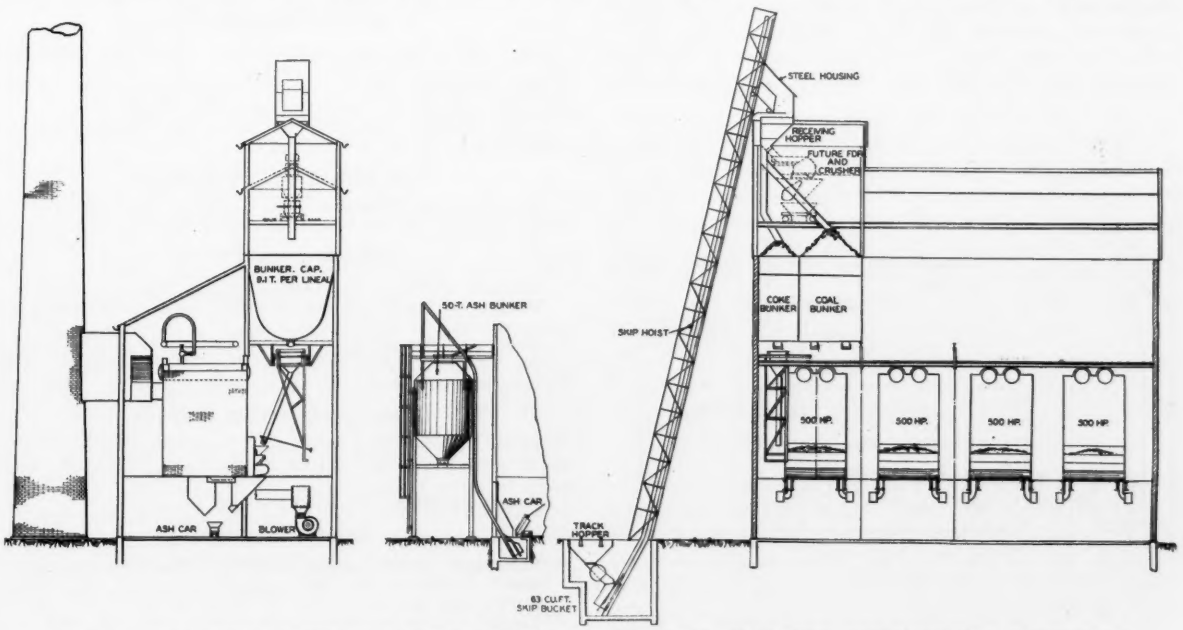


FIG. 3. ELEVATIONS SHOWING LAYOUT OF BOILERS, BUNKERS, COAL AND ASH HANDLING EQUIPMENT

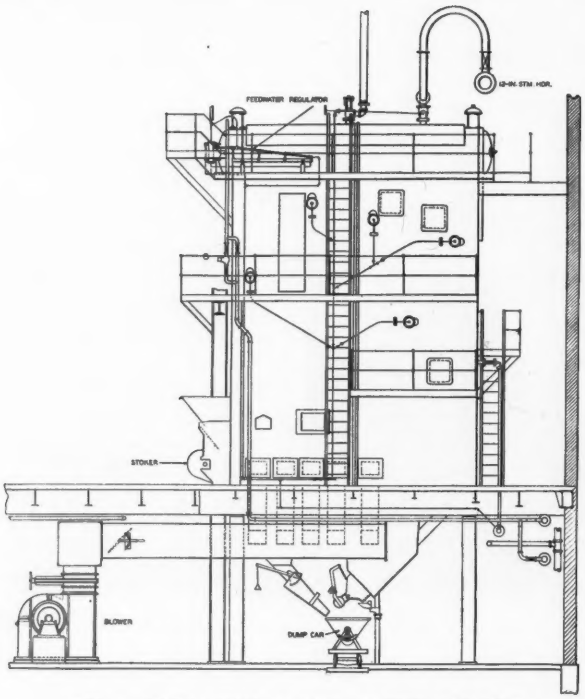


FIG. 4. ELEVATION OF ONE OF THE BOILERS

Fuel delivered into the track hopper drops into the bucket of a skip hoist which elevates it to the top of the boiler house. Here it passes through a steel housing into a receiving hopper. As may be seen from the drawings, there are two bunkers, one for coal and the other for coke. The bottom of the receiving hopper, therefore, is provided with a flapper gate which directs the fuel into either of two chutes, one feeding into the coke bunker and the other into the coal bunker. These bunkers are suspended over the firing aisle opposite boiler No. 1. Fuel drawn from these bunkers is distributed to the stoker hoppers by a weigh larry which runs the entire length of the present boiler room. This system is entirely adequate for the present plant but would not serve if the boiler house was extended. So provision has been made for the future installation of more bunkers and distributing system above them. The character of this equipment is shown in Fig. 3. It will consist of a feeder and crusher together with a tram car running over the top of the bunkers. The coal bunkers have a capacity of 9.1 t. of coal per lineal foot.

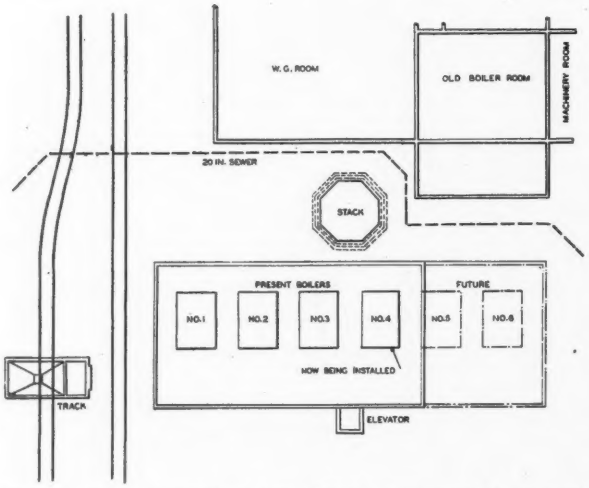


FIG. 5. PLAN, SHOWING RELATIVE LOCATION OF EQUIPMENT

Ash is removed from the plant by an industrial car running on tracks below the ash hoppers in the basement. At the present time a 50-t. outdoor ash bunker together with a skip hoist is being installed.

Forced draft for the stokers is furnished by two Clarage fans installed in the basement underneath the firing aisle. These fans feed into a common duct leading to the stoker wind boxes. The fans are provided with different types of drives, one being driven by an induction motor and the other by a Moore steam turbine. Ordinarily the fans are operated under automatic control, the electrically driven unit being fitted with a Brooke's fan regulator and the steam operated unit with a Foster Engineering Co. pressure regulator.

List of Equipment

GENERAL

Location.....Elizabeth, N. J.
Service.....Steam for Gas manufacturing plant
Drawings made by.....The Gas Machinery Co.

BOILER EQUIPMENT

Boilers—3 Babcock & Wilcox Co., straight tube water tube boilers, consisting of 2 new 500-hp. units and one old 400-hp. unit rebuilt to have a capacity of 500 hp.

Stokers—Harrington chain grate stokers 8 ft. wide by 13 ft. 2½ in. long with divided forced draft compartments. Riley Stoker Corp. driven by Vertical Troy engine and by Deihl electric motor through Reeves reducing gear.

Furnaces—Harbison-Walker Co. brick refractories, Johns-Manville insulating brick, American arches with a line 4 bricks high along the firing line of Carborundum brick.

Soot Blowers—Diamond soot blowers, 5 units per boiler.

Blow-off Valves—3 per boiler, A. W. Cadman & Co.

Feed Water Regulators—Copes, made by the Northern Equipment Co.

Damper Control—Brooke damper regulator.

Gage Column—Reliance—Reliance Gauge Column Co.

Safety Valves—4 in. Consolidated.

Ash Hoppers—Gas Machinery Co.

DRAFT EQUIPMENT

Fans—2 Clarage fans, one driven by a Diehl induction motor, the other by a Moore steam turbine.

Fan Regulators—Brooke regulator for electrically driven unit and a Foster pressure regulator for turbine driven unit.

Stack—Radial brick, 225 ft. high, 10 feet diameter at top. Capacity 2500 hp. M. W. Kellogg Co.

COAL HANDLING EQUIPMENT

Coal Handling Equipment by Link-Belt Co., consisting of skip hoist, coal and coke bunkers, travelling weigh larry.

FEED WATER SUPPLY

Treating System—Cold, zeolite softener, Paige & Jones.

Feedwater Heater—Foster Wheeler, closed type, using exhaust steam.

Feedwater Pumps—2, Buffalo Steam pump units, 2 Worthington Pump and Machinery Co. units, all steam driven with Foster pump governers.

INSTRUMENTS AND METERS

Boiler Panels—1 for each boiler, containing 1 Bailey boiler meter measuring steam and air flow, 1 Bailey multipoint draft gage.

Feedwater Meter—Bailey Meter Co.

MISCELLANEOUS

Steel work by Montgomery Iron and Steel Co.
Steam Piping—M. W. Kellogg Co.
Steam Pipe Covering—Chas. S. Wood Co.
Roofing—Johns-Manville—Transite.

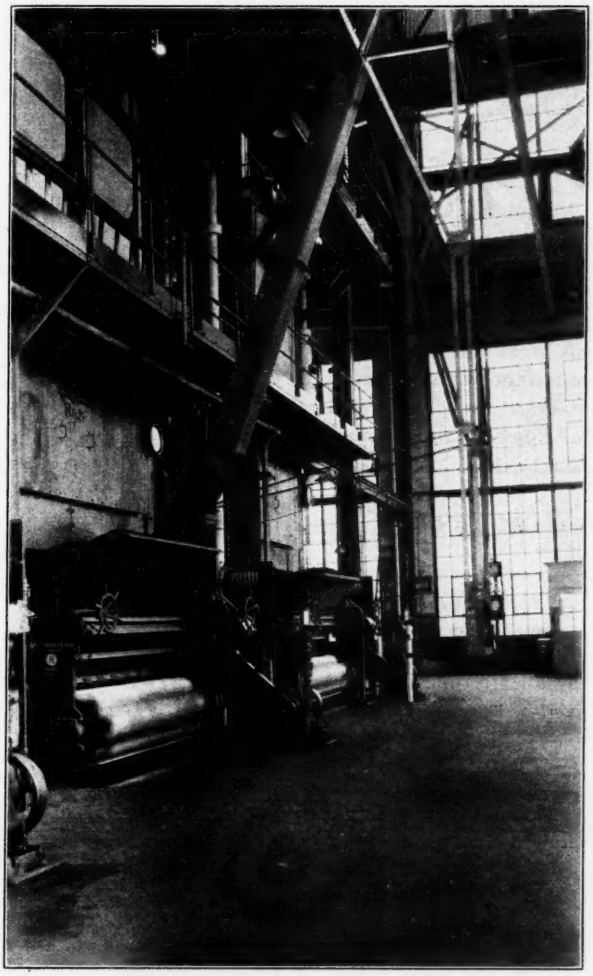


FIG. 6. COAL IS DISTRIBUTED TO THE STOKER HOPPERS BY MEANS OF A WEIGH LARRY

The boilers themselves are under the control of a Brooke's damper regulator.

There is a panel at the side of each boiler on which are mounted a Bailey boiler meter and multi-pointed draft gage. The boilers are fitted with the following accessories:

Diamond soot blowers, 5 units per boiler
Cadman blow-off valves—3 per boiler
Copes feed water regulators
Reliance gage columns
4 in. Consolidated pop safety valves fitted with a 6-in. atmospheric exhaust pipe.

Because of the large amount of steam used for process work which is not returned to the boiler, the question of water supply for the boilers is important. City water is used. This is excellent water but is treated by means of a cold, zeolite softener before passing to the feed water heater. The latter is a closed Foster Wheeler unit. An abundance of exhaust steam is available so this heater is considerably larger than present conditions require, but this again was installed with the ultimate plant in view. Four steam driven feed pumps are provided.

The arrangement of equipment in the plant is convenient and lends itself to efficient operation and maintenance. The plant, as will be noted, is quite high and an Otis elevator is provided for the convenient transport of passengers and material.

On the whole, though comparatively simple in its layout, this plant is a good example of the type of boiler plant suitable for a gas works in a growing industrial area.

New Plant Materially Reduces Labor Requirements

It is a great improvement over the old boiler plant which had all types of boilers, hand fired with low settings. In the old plant nine firemen were employed, but this in the new plant has been cut down to one man on each shift, there being three shifts.

Coal handling in the old plant required four men, bringing in coal and taking out ashes. In the new plant one man takes care of both hoisting coal and removing the ashes.

In addition to these savings in man power there is the saving brought about by decreased maintenance. The boilers in the old plant were small and had to be cleaned and furnaces repaired on the average every six weeks to two months. In the new plant it has been unnecessary either to renew any of the furnace linings or to do repair work of any kind since the plant was placed in service over a year ago.

Since the new plant has been in operation, the quality of the steam has improved considerably, a much drier steam being produced. This naturally has increased the efficiency of operation. Steam is used for various purposes, for operating steam turbines, to supply air to the water gas sets, for operating high and low pressure compressors, for pumping gas out into the mains and for the many pumps and auxiliary engines necessary for the operation of a gas works.

Exhaust Steam Used for Heating with Condensate Returned Through Oil Filters

Exhaust steam is run to a large header under 5 lb. back pressure and this is used for the generation of water gas. Condensate from the high pressure steam lines is run into a feed water tank and then returned to the boiler. The condensate from the exhaust steam lines, however, passes through an oil filter. Exhaust steam is used for heating the buildings in winter.

In conlusion, we wish to extend credit to John J. Crilly, the chief engineer of the plant, for his assistance in supplying us with the material on which this article is based and for courtesies extended during our visits to his plant. Mr. Crilly is responsible for the design of this plant and it was erected under his supervision.

Purdue's New Power Plant Extension Reduces Cost of Operation

In the lists of equipment which accompanied the above article starting on page 368 of the September, 1933, issue, two items of equipment were inadvertently omitted. These items include four 2½ in. and eight 2 in. Yarway Tandem Blow-off Valves, made by Yarnall-Waring Co., and four Copes Regulators, made by Northern Equipment Co.

POWER PLANT ENGINEERING October 1933

Gage Board Design *for Power Stations*

Little has been published on this Important but usually overlooked Feature which means so much to the Operating Crew. These practical pointers, the result of years of Design Experience, summarizes the practice of a recognized leading firm of Power Plant Designers

By GUSTAF A. GAFFERT

THERE WAS A TIME when little, if any, effective use was made of instruments in the power plant. The few that were used were located individually near their respective pumps, heaters or fans to suit the fancy of the erector. We have progressed rapidly of late from older inefficient operation to highly efficient operation, particularly in the boiler room, and have come to look upon centralized control for skilled operators as economic design conducive to good operation.

The number of centralized locations for instruments depends largely on the type and size of plant. Expenditure of money to install many refined instruments may not be warranted in a small industrial station yet be an economic necessity for a base load central station which must watch its heat rate critically. Practically all plants can afford a boiler gage board, involving the usual indicating steam pressure, draft and boiler steam output gages since so great a percentage of the plant efficiency as a whole depends upon the maintaining of proper combustion. In larger plants a turbine gage board housing all the gages showing turbine throttle conditions, stage pressures and extraction heater performance is common practice. Central stations are so complicated and occupy so much floor space that often it is advisable to install a central gage board for the various pumping units as well. In stations where there exists a bay between the turbine and boiler room known as the heater bay a centralized board housing gages and thermometers for all the heater apparatus also may be justified. Finally it becomes necessary in central stations to collect on one or more central boards, strategically located, a few gages such as steam pressure and load demand.

Consult the Operator

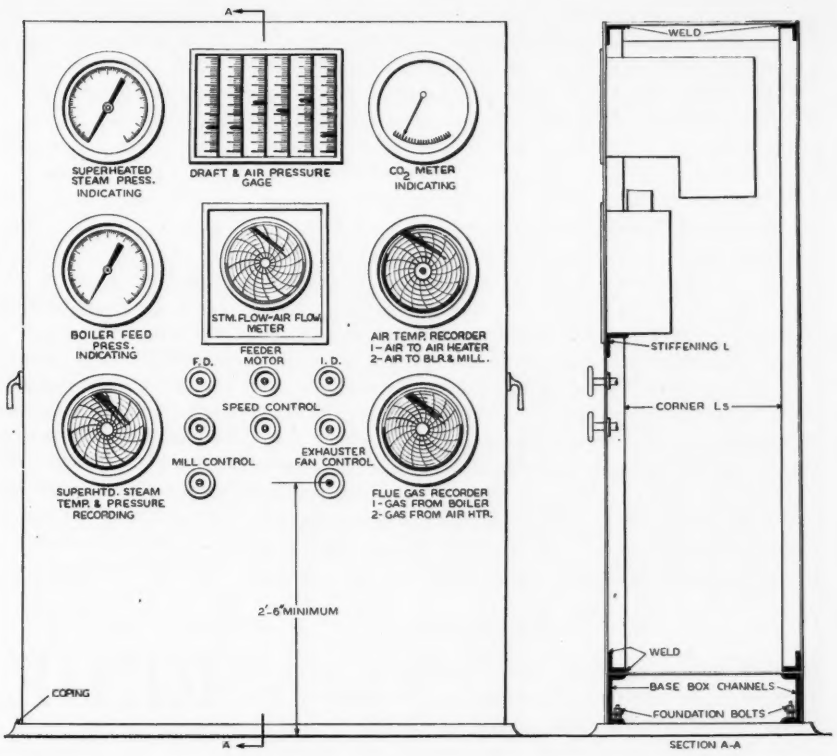
With regard to the location of these various boards only general statements can be made unless a particular station arrangement is under discussion. Some points can, however, be stated which are common to all installations. In the case of a boiler gage board two arrangements are popular, one with the face of the board perpendicular, and another with the face of the board parallel to the firing aisle. In the former the face of the boards are often lined up with the aisle between boilers and facing one another. This enables one man to watch the performance of two boilers from practically one spot. A criticism of this arrangement is that the operator, when in front of the boards, does not have an unrestricted view down the firing aisle, and may not be able to see the gage glasses on the water columns.

In the second arrangement the edge of the boards may be lined up with the aisle between boilers, the boards being either in the same relative position with respect to the front of the boiler or one board on each side of the common boiler aisle. Again, the boards may be placed out from the front of the boiler on the other side of the firing aisle. It is quite possible with this arrangement to stand in one spot and be able to observe conditions as shown by gages on the boards, note the steam or load demand on the master gages, and observe the water column.

Turbine gage boards should be so located that the turbine operator can see what is happening when he stands at the throttle valve. The boards may be either in line with the axis of the turbine and the front perpendicular thereto, or located at the side of the turbine. Master gage boards in the boiler room usually include an illuminated steam pressure gage and load indicator and should be visible from all points along the firing aisle. In the location of all these control and gage boards the operator should be taken into the confidence of the designer to produce an easily operated as well as well designed board.

Flush Mounting Improves Appearance

With the concentration of operating gages and thermometers on central gage boards more attention must be given to instrument style and size. Some instruments serve only as an indicating guide while others record events, necessitating consideration of both types. Again some instruments are for the purpose of indicating trouble while others are for the purpose of checking continuously the performance of certain equipment. In general all instruments are made with either round



LAYOUT OF A TYPICAL WELL DESIGNED CONTROL PANEL

or rectangular cases. When considering a board layout the style, size and shape of case have a material effect on the dimensions of a board. The so-called 10-in. dia. case is popular although the 8-in. case will probably be satisfactory and slightly cheaper for the small plant. The size of the divisions and legibility of the figures at a distance are important features.

Lately, with appearances becoming more important, flush mounted cases are being used. Obviously all, if any, gages on one board should be flush mounted. This produces a pleasing appearance in the uniform front of the board and reduces the dust and dirt accumulation on top of the customary panel mounted gages. It does of course increase the depth of the board when clearance must be allowed for working space behind the board. The cost of such a layout is little, if any, greater than a panel mounted board, many flush mounted gages being obtainable at no extra cost. The cutting of the front plate for insertion of the instrument cases is then the only major first cost increase.

When indicating and recording gages and thermometers are placed on the same board, the cases may well be of the same design, usually the design of the recorder case. Black baked enamel cases, with rings finished in the same manner or chromium plated rings are quite satisfactory.

Although it may appear that a given number of gages can be grouped in any manner on a given surface of a gage board, there are usually one or two preferred layouts. Indicating instruments are most easily read somewhere near the eye level. Recording instruments are not read as often as indicating gages and carry charts which have to be changed periodically, thus fortunately demanding a different location than indicating instruments. Switches and speed control rheostats for fans, stokers and mill feeders must be frequently adjusted and should be located at a height not much higher or lower than an operator's waistline so that he will not have to reach or stoop to change the control setting.

From these considerations alone it appears that indicating instruments should be mounted on the upper part of a gage board and recording instruments on the lower part of the board. Important indicating gages should, in general, be located on the top row and include steam pressure, draft and air pressure, gas and oil pressure gages, and CO_2 indicators. Less important indicating gages should occupy the second row and be so located that gages associated with the same pressures and temperatures come directly under or aside of one another. While round case temperature recorders may cost less than a multi-point roll type recorder, the saving of space on the board must be given consideration. The board can then be laid out a number of different ways and a good combination selected.

Balanced Design

The theory of what might be called balanced design may well be employed in making the final layout. Starting with the vertical center line of the board the various indicating and recording gages are laid out so as to straddle this imaginary line giving a balanced board. There are, of course, a number of possibilities. A typical gage board layout is shown by the drawing. It is assumed that a single draft and air pressure gage is employed and is centered, as indicated, slightly above the eye level, a straight line type being shown. The important steam pressure and CO_2 indicating gages are placed on the same level as the draft gage and so as to balance it. The boiler output is recorded on the steam

flow meter on the vertical center line below the draft gage. All associated pressure gages are placed in the same vertical column and, for symmetry, on the same vertical center line. It is assumed that pulverized coal is being burned, the controls being symmetrically grouped at a convenient height below the flow meter. The associated flue gas and air temperature recording thermometers are also grouped together.

Dimensions of gage boards may be determined from a consideration of convenience and clearances. If the position of the lowest control or recorder be taken as 2 ft., 6 in. above the floor level and the height limited to approximately 7 ft. for reading of indicating instruments, this one dimension is fixed. Again clearances must be considered between individual instruments and 2½ to 3 in. between outside of dials on round cased instruments or projecting parts on rectangular cased instruments is usually satisfactory. Great care must be taken to allow working clearances for rheostats and levers, as well as clearances for making pipe connections behind the board. This is of greater concern with flush mounted instruments than with panel mounted gages.

Working Clearances

By observing clearances and balancing the design of the board the width is determined. The depth of the board is determined from working clearances. If a board is backed up against a wall only side entrance is possible and a depth of 2 to 3 ft. is necessary. With flush mounted gages some instruments project far enough into the housing to become a limiting factor for depth. Structural features must also be considered since the front of the board being a relatively large surface must be braced. If a slot is cut in the floor for bringing in the piping and electrical wiring, with flush mounted gages the piping and wiring can be tucked in around the instrument cases in a workmanlike manner running all connections horizontally and vertically and parallel or perpendicular to the board.

When combustion control is used, the board, in the case of a boiler board, becomes more complicated, but in general the added controls can be symmetrically grouped on the front. The lower inside surface of the front of the board can be used to locate junction boxes, terminal blocks and resistors, in the case of an electrical system or shafts and levers in the case of a mechanical system. Operative controls should be brought up to minimum height above floor and project through the front of the board. If combustion control is to be added at a later date, this space must be estimated and allowed for, although it may work out as well to consider the combustion control separately when it is installed.

Structural

Structural features of gage boards must be given careful consideration for several reasons. Vibration has been known to cause false operation of relays and false registration of recorders. One remedy is to build the board of material not thinner than a certain thickness, and to place an absorbing footing under the board in such a way that the transmitted vibrations are damped out or diminished to a negligible quantity before they reach the board proper. Boards built of thin sheet steel and inadequately braced are susceptible to resonance if placed near rotating machinery.

A box type of board may be constructed of structural channels and angles somewhat as indicated by the drawing and the whole structure riveted or welded together. Welding produces a neat job and is representative of modern practice. While in the shop the front plate may well be cut for the various flush mounted instruments. Bearings for control shafts and all stiffening steel should also be added. To make a smooth appearing job the front plate may be run down over the base channel or frame and on the sides to the very edge.

Depending upon the location, type and money to be spent in good design the board may be finished on the exterior either as a plain box or with an edge trim. Metal molding produces an artistic touch to an otherwise plain board while if the board is to be located in a rather conspicuous place the exterior may be sand blasted and finished with a few coats of enamel or duco to give a striking background contrasting with the various instruments mounted upon it.

REHEAT—

Practice, Operation and Control

AFTER A REHEAT BOILER is in regular operation, control of the temperature depends upon the details of station design. If separate reheat boilers are used, reheat temperatures are controlled by the rate of firing. Obviously this cannot be done where reheat coils are located in each boiler as the rate of firing depends upon the steam demand. In this case several schemes are in use as described in previous articles.

At Lakeside and Port Washington characteristics of radiant and convection superheaters and reheaters are taken advantage of to give constant temperatures at all loads without further control equipment[1]. With the usual convection reheater, a steam reheater in series is used to do some of the heating at light loads and counteract the natural drooping characteristic of the convection reheater. Control of the steam reheater is accomplished in two or three ways[2]. At South Amboy the steam supply to the steam section is throttled while at Ilse the reheater drain is throttled, the practical result in each case being a reduction in reheater surface by flooding.

At Station A the steam reheater is bypassed and at high loads the steam to the gas reheater is desuperheated by using No. 1 heater which normally uses steam at cross over pressure. In this station the steam reheater, supplied with saturated steam at boiler pressure, is located in a vertical position and high enough for the condensate to drain back to the drum by gravity. A diagrammatic arrangement is shown by Fig. 1.

Valves in the steam and water lines connecting the reheater to the boiler drum are open at all times.

[1] See Power Plant Engineering, p. 807, Dec., 1932.
[2] See Power Plant Engineering, p. 588, Aug. 1, 1932.
[3] See Power Plant Engineering, p. 486, July 15, 1932.

Exhaust from the high pressure turbine first passes through the steam reheater to the gas reheater and then to the low pressure turbine.

Regulation of the final reheat temperature leaving the gas section is controlled by the operation of valves A, B and C of Fig. 1. At light loads the steam reheater is in full use and valves A and C are closed and valve B wide open. Steam temperature leaving the high pressure turbine (operating at variable exhaust pressure) and entering the steam reheater increases with the load as shown by Curve 1-1 Fig. 2. With no control reheat steam leaving the steam to steam reheater would normally be heated up to about 545 deg. F. as shown by the Curve 2-2. Due to the characteristics of convection reheaters, this would give excessive reheat steam temperatures at loads in excess of about half the maximum. To obviate this the bypass valve A starts to open at a load of about 225,000 lb. of steam (A of Fig. 2) and is completely opened at about 325,000 lb. (B of Fig. 2).

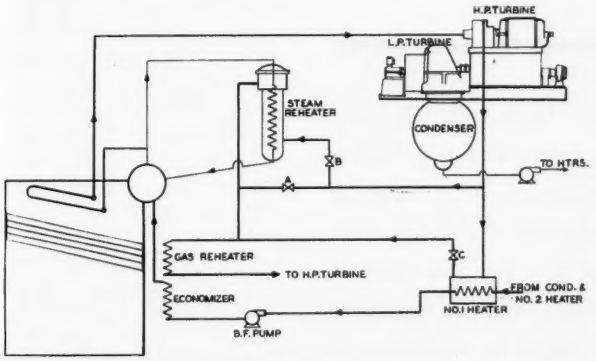


FIG. 1. ARRANGEMENT OF REHEATERS AND VALVE CONTROL AT STATION A

At this point valve B at the inlet to the steam reheater starts to open forcing more of the steam through the bypass. At a load of 400,000 lb. per hr. valve B (C of Fig. 2) is completely closed and the steam reheater is completely out of service. At this point valve C starts to open and No. 1 heater (ordinarily operated as a dead end heater) acts as a desuperheater. At a load about of 450,000 lb. of steam (D of Fig. 2) valve C is wide open and steam flowing from the high pressure turbine to the gas reheater passes through two paths connected in parallel; the bypass valve A and the No. 1 heater through valve C. All these valves are motor operated and controlled automatically.

The temperatures are shown in Fig. 2 as a function of the boiler output. Curve 1-1 is the temperature of the high pressure turbine exhaust which is of course the temperature of the steam entering the steam reheater; Curve 1-2 is the temperature entering the gas reheater; Curve 3-3 is the temperature leaving the gas reheater; Curve 4-3 is the temperature leaving the gas reheater when the steam reheater is not used. These curves show conditions under automatic control and it must be remembered that the station has one standard boiler; two reheat boilers and two 50,000 lb. steeple compound turbines so that considerable temperature regulation can be accomplished by changing the rate of firing of the boilers[3].

Desuperheating by means of the No. 1 heater has been entirely satisfactory and was accomplished in a simpler way and with fewer complications than a spray arrangement. The heater is also used as a desuperheater in emergencies when the high pressure turbine is out of service and it is desired to operate the low pressure turbine. Under these conditions of operation the steam reheater is bypassed, the high pressure steam passing through the high pressure turbine control valve and orifice, which are used only under these conditions, to the No. 1 heater where it is desuperheated.

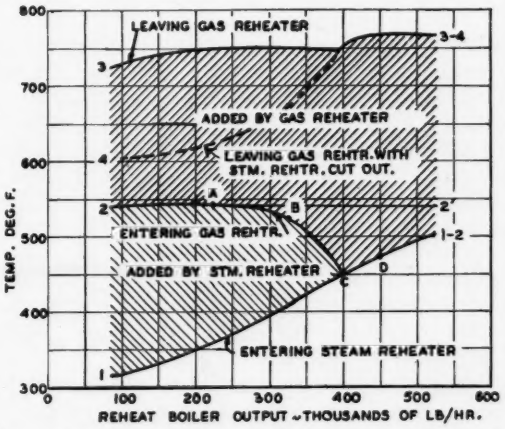


FIG. 2. CURVES FROM STATION A SHOW THE EFFECT OF THE STEAM TO STEAM REHEATER

Automatic control is provided with a potentiometer installed in the steam line leaving the gas reheater acting as a master controller. The control as installed allows automatic, semi-automatic or push button control. Signal lights indicate the position of the selector switches and the open or closed position of each valve.

Diesel Engine Costs

"CERTAIN FUNDAMENTAL economic questions must be settled if Diesel engine installations are to fill current financial requirements," declared Otto Nonnenbruck at a recent meeting of the Boston section of the American Society of Mechanical Engineers. "It costs from $80 to $100 a kilowatt to put in a Diesel plant, if all expenses are included," the speaker stated. "This means that the installation must earn at least $15 a year per kilowatt of capacity to cover charges. If each kilowatt of capacity in such a plant turns out 3000 kw-hr. per year, these charges then reach 5 mills per kw-hr. Fuel oil, lubricating oil and repairs call for another 5 mills. The labor requirements of a three-shift installation can hardly run under $1500 per man, or $4500 total, and this means 2 cents per kw-hr. attendance cost for a 100-kw. plant and 2 mills for a 1000-kw. set-up. Thus the overall requirements may be expected to range from about 1.2 cents to 3 cents per kw-hr."

The speaker also emphasized the desirability of getting rid of all possible complications in Diesel engine design, and pointed out the importance of developing an engine which can be run from six months to a year without stopping. Uniformity of appearance and general assembly features are also desirable.

POWER PLANT ENGINEERING October 1933

Transporting Steam at 4

A Description of the Steam Distribution System Between the New Mercury Vapor Power Station and the Works of The General Electric Co. at Schenectady.

AMONG THE many features of interest regarding the new outdoor mercury-vapor-steam power station of the General Electric Co. at Schenectady one of the most important was the design of the steam lines between the power station and the General Electric works. These lines convey steam for heating, turbine testing and for manufacturing purposes from the new power plant to distributing points in two old power stations. The total distance involved is 3735 ft., requiring the installation of 4865 ft. of 14-in. high pressure lines and 4433 feet of condensate return lines, mostly 8 and 10 in. Steam is delivered at 400 lb. and 750 deg. F. at a maximum rate of 500,000 lb. per hr. The transmission of so much energy through this distance together with the high temperatures, high pressures, and the accompanying expansion problems made this a major piece of work, adjunct as it is, to one of the most interesting power stations in the world.

IMAGINE a 20,000 kw. boiler plant feeding its entire output into a pipe line less than a mile long and yet no steam coming out at the other end. Preposterous, you say! Well that is just about what would happen if the pipe line described in this article had no insulation. Without insulation the radiation at 750 deg. would be equivalent at more than 20,000 kw. or the output of the mercury turbine. ¶Here are other startling facts regarding this line: ¶One and three-quarter miles of welded steam and return pipes. ¶Four hundred pounds, 750 deg. F. delivered. ¶Flow of a half million lb. per hr. ¶Two and a half tons of steam en-route. ¶Linear expansion of pipe, 30 ft. ¶Potential thrust of pipe, 400,000 lb. ¶Welding cost 3 per cent of pipe line cost.

All the high pressure steam lines and the condensate lines with their steel accessories were fabricated by electric arc welding. Arc welding was used because of the desire to eliminate flanges and gaskets and to provide a line of one continuous piece of metal.

Details and the general design of the mercury-vapor power station were described in a previous issue. The entire electric output of 26,000 kw. is delivered to the lines of the New York Power and Light Corporation while the steam output goes to the "Schenectady Works" for purposes already mentioned.

The 20,000 kw. mercury vapor boiler and outdoor turbine generator has a byproduct steam output from its condensers and combustion-chamber water-walls of 330,000 lb. per hr., while a steam boiler delivers an additional 300,000 lb. per hr. A non-condensing 6000 kw. outdoor steam turbo-generator is a part of the power station equipment. The available steam output—a half million pounds per hour—will go to the Works, and all condensate will be returned to the new power station.

The steam and return lines are carried in an 8 ft. high by 8 ft. 6 in. wide reinforced concrete tunnel having 10-in. walls and built about half in the ground. The final grade in the area will be two inches above the roof of the tunnel. Short sections where entry is made to Buildings No. 13 and 61, the old power stations, are carried on skeleton bridges, because they cross a trolley line, city water mains, a street, the abandoned Erie Canal and other obstructions. Eventually, these obstructions will be removed and the tunnel terminals will be completed.

The tunnel is drained by gravity to sewers, adequate lighting is provided, hatchways are available at 400 ft. intervals and exhaust fans are similarly spaced. The lights may be switched on in either direction from the hatchways, the hatchways are large enough to allow 35 ft. lengths of 14 in. pipe to be taken through them. Five exhaust fans will remove heated air and vapor, drawing fresh air through louvers at inter-points. These provisions are made so that periodic inspections can be made and work can be done comfortably and safely even in the event of a leak in a steam line. The use of these fans facilitated welding operations as temporary ventilation system would otherwise have been required.

In service, the 14-in. high pressure lines contain 2½ tons of steam, traveling at a speed of 4000 ft. per minute. The temperature rise to 750 deg. F. involves, in the 4865 ft. of 14-in. pipe, a total linear expansion in the neighborhood of 30 feet with a potential expansion pipe thrust of 400,000 lb. Without insulation, the radiation at 750 deg. F. would be the equivalent of more than 20,000 kw. or the output of the mercury turbine! These figures

[1] Features of the Outdoor Mercury-Vapor Steam Plant at Schenectady. Page 354, August, 1933, issue.

t 400 Lb., 750 Deg. F.

By
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Industrial Engineering Dept.
General Electric Co.

make evident the responsibility of the anchorages, the expansion joints, the welded joints and the insulation.

The high pressure piping is seamless, has a half inch wall and the 35-ft. lengths weigh about 2300 lb. They were tack welded to form 200 ft. lengths and the welding of the joints was completed as the sections were rotated. Position welds joined them to flangeless slip expansion joints as shown in Fig. 2. These slip joints in turn were welded to H sections embedded in the tunnel side wall, thus providing a rigid anchorage. Self sealing packing is used under light mechanical pressure as the steam pressure tends to press the truncated-cone rings against the pipe. The joint provides for 18 in. expansion of which from 14 to 16 in. will be required.

Weld-fabricated compound roller supports are located under the pipe 12½ ft. each way from each expansion joint. One member is welded to the pipe, the other to a suitable structural steel support and three 2-in. cold rolled steel rollers are installed between the members. Vertical rollers at the sides prevent twisting or swaying. Throughout the length of the pipe, at 25-ft. intervals, are located spool-type roller supports. The curved plate that moves with the pipe is welded to the pipe through small pipe spacers to allow space for insulation and to minimize heat transfer. The spool carrying member is attached to a table plate which in turn is welded to the two channels embedded in the concrete side wall. The table plate is further supported by structural legs and braces, which also carry the 10-in. or 8-in. return line. Details of supports and anchorages are shown in Fig. 3. Approximately twenty-two 90-deg. bends were used; those leading to the bridges are of 12-ft. radius. In general, anchor brackets were welded to the short radius bends and in turn to H frames embedded in the concrete walls or roof. Where an expansion joint is close to an elbow, it is mounted on a roller support instead of being anchored.

Bridges Independent of Piping

Two kinds of construction were used in building the bridges. The parts nearest the tunnel are built to carry the pipe by suspension, to allow for the expansion of the vertical runs. The suspenders are spring-supported on the bridge and are welded to rings which encircle the pipe and give it point support underneath, so that the pipe can be lifted or it can move forward or back without imposing an extra strain on the bridge structure. The pipe next to the buildings is mounted on top of the bridges. A continuous H section is laid between the bridge and the pipe in order to relieve the structure of possible expansion strains. Should an expansion joint in the pipe fail to slip, the strain will be placed on the practically independent H section rather than on the bridge structure proper. The pipes are carried on multiple roller supports spaced every 25 ft. throughout these sections. The weld-fabricated bridges are constructed with expansion joints at regular intervals and are entirely independent of the pipes they support.

The steam pipe to building No. 13 branches in the building to a 4000-kw. non-condensing turbine, and to a reducing valve and desuperheater for furnishing manufacturing steam at 130 lb. pressure. Exhaust steam from the turbine heats office and factory buildings at the northeasterly end of the plant. The return water is collected in a large reservoir which feeds by gravity to return water pumps so designed and motored that they suit the output to the head imposed and require no manipulation to meet varying conditions. The two high

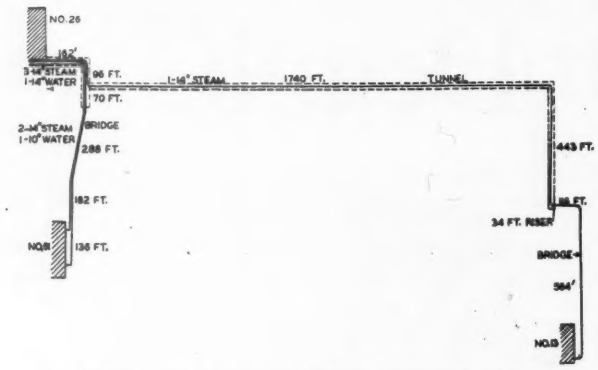


FIG. 1. PLAN OF THE TUNNEL AND BRIDGE

pressure steam lines enter building No. 61 at different points for operating condensing and non-condensing turbines of 20,000 kw. output, and to furnish manufacturing steam. For a time steam will be furnished to No. 61 at 225 lb. and the desuperheaters are located at the new power station. The exhaust steam from the non-condensing turbines goes to heat the buildings in that zone of the works. Return water is pumped to an elevated tank in building No. 61 from which it flows by gravity to the new power station. Return water from building No. 13 joins that from No. 61 in the tunnel and also goes to the new station. In event that the new station is not taking the water, No. 13 return goes to the tank in No. 61, hence the pumps in No. 13 do not have to be stopped or regulated. A check valve in No. 13 return line prevents a possible back flow.

During the transition period it was necessary to deliver steam from No. 61 to No. 13 to furnish heating steam through the 4000 kw. non-condensing turbine for factory buildings as the boilers were being removed from No. 13. This necessitated immediate insulation of the pipes as the bare pipe radiation would have dissipated most of the heat. The insulation was completed before the joints were tested and upon applying the 225 lb. pressure available, no leaks developed.

The versatility and economy of arc welding fabrication are illustrated by the above requirement, i.e. temporary steam supply to come from No. 61 to No. 13. Holes were cut in one line to No. 61 and in the line to No. 13 and a 10-in. crossover was welded in place close to expansion joints. As soon as the new station is ready to furnish steam, the crossover will be removed and new short sections of pipe will be welded on the main lines at the expansion joints. This changeover, it is estimated, will require only a few hours' work.

All the high pressure lines are insulated with 1½ in. of Super X and two inches of 85 per cent magnesia. A waterproof cover is held in place by wire winding and the whole surface is painted. Covering at the expansion joints is removable and is retained with hinged copper jackets with provision for ventilation and drainage. A small vent collects and makes visible any steam leakage at the joint.

Fabrication of Pipe Lines in the Tunnels

Stands for the expansion roller supports were fabricated and welded in place. The pipe was brought in through the hatchways and hauled to location on trucks. Fusion rings 1 in. wide by ⅛ in. thick, rolled from strip, were tack welded in the delivery end of each pipe, the welds being made at the inside edge of the ring within the pipe. The lengths were then lifted onto the stands and placed on temporary roller dollies. Six lengths, with the last one cut to make approximately 200 ft., including the chromium plated sliding section in the expansion joint, were strongly tack welded together at six points at each joint. A split gear was clamped on and the 200 ft. length was rotated at about one revolution in six minutes, or at a peripheral speed of a little over 7 in. per minute, by a small adjustable speed motor operating through a gear reducer and chain.

The welding of roll joints involved five passes using heavily coated G-E W-21 electrodes, starting with 3/16 in. at 200 amp. and finishing with ¼ in. at 275 amp. After each pass the slag was chipped off with an air tool which provided some peening effect. The first pass was laid straight and succeeding passes were oscillated increasingly as required to fill the 60 deg. beveled groove. The last pass was slightly crowned and was about ¾ in. wide. The welding was all done by hand, using single operator type motor-generator welding sets.

Only one position weld was required at each expansion joint, that being where the 200-ft. line was welded to the stationary member of the expansion joint. These position welds were made with G-E W-20 electrodes in 4 passes. The weld passes were started at the bottom of the joint and finished at the top, alternating the halves. The succeeding passes were started and finished at staggered points to prevent concentration of starting and finishing joints.

After the position welds, the roller dollies were removed and the roller support members were welded to the underside of the pipe and to the stands. The expansion joints were then anchored by welding. Fitted

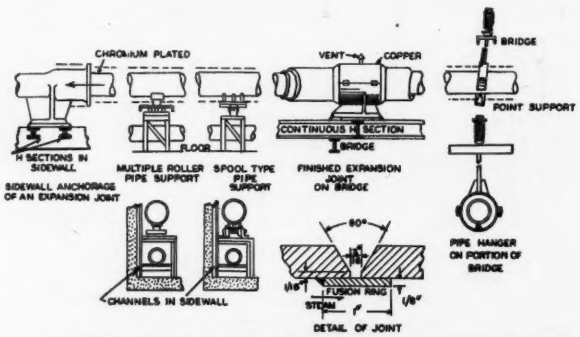


FIG. 2. DETAILS OF PIPE, SUPPORTS AND ANCHORAGES.

blocks were welded between the embedded H section and the joint anchorage bases.

The 8-in. and 10-in. water pipe was handled in the same manner as outlined above except that the expansion joints were spaced 400 ft. apart. The expansion joints were fitted with anchorage members by the manufacturer but the anchorages on the bends were fabricated at the Schenectady Works. The vertical risers, two of 28 ft. and one of 34 ft., were position welded with G-E W-20 heavily coated electrodes.

Thirty welders from the regular Works production personnel were qualified through the Hartford Steam Boiler Inspection and Insurance Co. for welding Class I pressure vessels under the A.S.M.E. Boiler Code. The welders who fabricated the pipe lines were from this group. They were required to make roll and position welds, similar to those tested required on the pipe line.

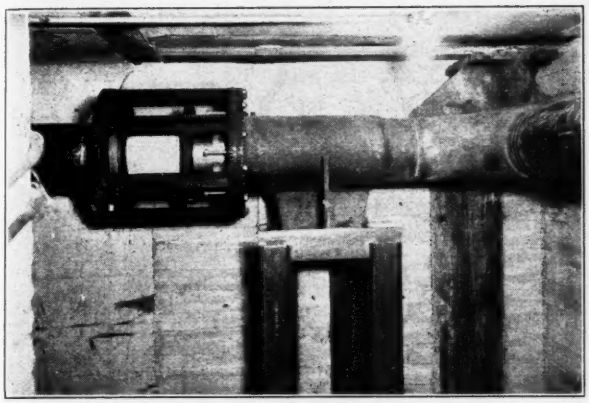


FIG. 3. ARC WELDED SLIP EXPANSION JOINT AND ELBOW IN 14 IN. 400 LB. 750 DEG. STEAM LINE

Nine test specimens from tested welds were subjected to reduced-section tension tests, nick-break tests and bend tests. Specifications, covering in detail, the entire welding procedure were rigidly adhered to throughout the fabrication of these pipe lines. It is significant that not a single leak developed under steam test among the great number of roll welds and horizontal and vertical position welds.

The electrodes used on the pipe and accessories amounted to 2155 lb. The welding cost was 3 per cent of the cost of the line exclusive of tunnel and bridge construction.

Reconnecting A Motor From Series Delta to Star

Despite the complexity of motor windings it is often a simple matter to reconnect the windings of a motor so as to adapt it to a different voltage.

By C. C. Herman

ONE OF THE SIMPLEST reconnecting jobs is to reconnect a series delta winding to series star. The object of such a change is, of course, to utilize the motor on a higher line voltage as for instance where the normal motor voltage is 220 and the line voltage is somewhat higher, say 440 v. Theoretically the changing of the motor to series star connection will not increase its voltage by two, however, it is near enough to make it practical and many motors have been changed, giving good operating results after the change.

In a delta connected motor the volts per phase is the same as the line voltage. If the line voltage is 220 v. then the volts per phase of the delta connected motor is also 220 v. Obviously if the line voltage were increased to 440 this motor could not operate satisfactorily for any length of time as it would heat excessively. It is noted, however, that the volts per phase of a star connected motor is equal to the line voltage divided by 1.73, therefore, if the volts per phase of the delta connected motor is 220 the volts per phase of the star connected motor would be 127. If the line volts were increased to 440 then the volts per phase of the star connected motor would be 255 or 35 v. higher than it is for the delta connected motor working on a 220 v. line. Theoretically the line voltage for this motor connected star should be 220 times 1.73 or 380 v.

Fig. 1 shows in diagrammatic form the delta series winding for a four pole three phase motor having a synchronous speed of 1800 r.p.m. Fig. 2 shows the corresponding series star connections for this same motor. A close study of these figures shows that the only operation is the severing of the A1 lead from the B phase, the B1 lead from the C phase and the

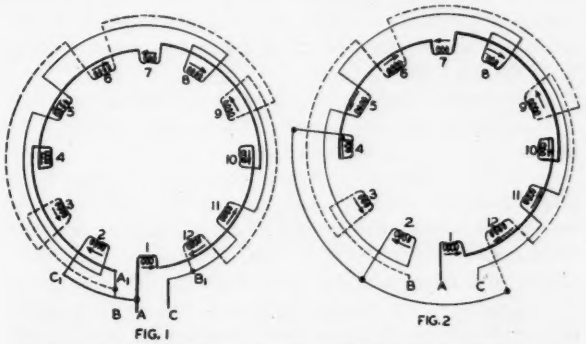


FIG. 1. FOUR POLE, 3 PHASE, SERIES DELTA WINDING
FIG. 2. FOUR POLE, 3 PHASE, SERIES STAR WINDING

C1 lead from the A phase, then tying these ends together in star manner as indicated in Fig. 2. Before cutting these connections loose in the delta winding it is advisable to check the groups with a diagram to be sure that the correct ends are found for if the wrong ends of the respective groups are cut something entirely different will obtain. It is a good practice to first locate the groups from which these ends should come. The A wire from group 1, the B wire from group 3 and the C wire from group 11. Also note from which side of the respective group these wires come. Then locate the A1 wire from group 4, the B1 wire from group 12 and the C1 wire from group 2 and tie these wires together.

Before tying these wires together it is advisable to test out the phases with a test light or megger, preferably the megger as it gives more accurate results at the higher voltage. Test, not only between phases but from each phase to ground. If the test shows clear then the ends may be twisted together and soldered. Insulate the wires with varnished cambric and friction tape and then fold the excess wire back neatly. The wires should be tied down with strong cord or in lieu of cord use loom.

If the winding tests rather low with the megger it may be brought up in resistance by cleaning it thoroughly and giving it a coat of finishing varnish.

POWER PLANT ENGINEERING October 1933

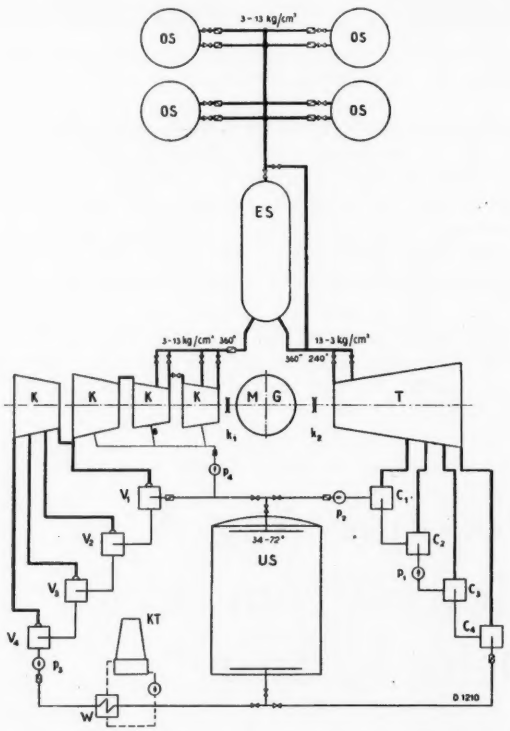
New *Heat Storage System* Developed in Europe

DR. F. MARGUERRE, WHO DEVELOPED THE NEW CYCLE, DESCRIBES ITS OPERATION IN THE ESCHER-WYSS NEWS. LOW FIRST COST AND PRACTICAL STORAGE OF NIGHT ENERGY FROM STEAM OR HYDRAULIC PLANTS SAID TO BE CHIEF FEATURES

FUNDAMENTALLY the working principle of the process is best explained by comparing it to that of a hydraulic pumped storage plant. Just as there water is pumped from a low to a high level by utilizing surplus energy and the energy recovered by allowing this to fall from the upper to the lower level, so here, in the thermo-dynamical province, heat is pumped from a low to high temperature level by means of the heat pump (turbo-compressor) and the energy recovered in a steam turbine during the temperature drop from the high to low level.

Materially, the process is carried out as follows. Water vapor, and consequently heat, is withdrawn by means of a turbo-compressor driven by surplus energy, from a water storage reservoir at a lower temperature level, compressed and condensed in an upper water storage receiver which stands at a higher pressure. This upper accumulator is then discharged through a steam turbine producing peak load in the usual way, the exhaust steam being condensed into the lower reservoir, returning to it the same amount of heat as previously withdrawn. This cycle then begins afresh.

Figure 1 gives a general diagram of the plant on which are entered as examples some temperature and pressure values which for average outputs will give satisfactory results. In the middle of the diagram is the electrical machine, marked with MG, which alternately works as motor and generator and which by means of the movable couplings k_1 and k_2 may be coupled either to the compressor K during the charging period or to the turbine T when discharging. Above in the middle part are the upper storage reservoirs OS, with the superheat accumulator ES below. In the lower part of the diagram, in the middle, is the lower storage reservoir US, on the left of which is the group of evaporators V_1 to V_4 which belong to the compressor, and on the right of which are the group of condensers C_1 to C_4 which belong and are connected to the turbine.



MG Motor and generator
k_1, k_2 Movable couplings
K Compressor
T Steam turbine
OS Upper storage reservoir
ES Superheat accumulator
US Lower storage reservoir
V_1—V_4 Evaporators
C_1—C_4 Condensers
KT Cooling tower
W Heat exchanger
p_1—p_4 Pumps

FIG. 1. DIAGRAMMATIC REPRESENTATION OF A MARGUERRE HEAT STORAGE PLANT

DISCHARGE CYCLE

For the working description it is assumed that by means of an initial charging of the plant, which will be dealt with later, the normal temperatures are already attained. First the process of discharge will be described and then that of recharging. The upper storage reservoir which works in a similar manner as the Ruths accumulator, stands under a pressure of say, 10 to 12 atm. (140 to 170 lb. per sq. in.) at the beginning of the discharge. On opening the reservoir valves the steam passes through the main steam pipe to the superheating accumulator ES (which is provided with a by-pass) and from there to the turbine. Steam flows through the turbine to the four jet condensers C_1, C_2, C_3 and C_4 through which, one after the other, the water from the lower storage reservoir is forced.

As the condensers are fed with water from the lower reservoir US, which is under atmospheric pressure, the cold water flows by itself to the condenser C_4 which stands under vacuum. The quantity of water is regulated by the influence of a temperature regulator. The condenser apparatus is subdivided into four stages in order to reduce the difference between the useful temperature (and hence pressure) drop between the two main accumulators in the charging and discharging process. The water is fed through the four condensers partly by gravity under control of a water seal, partly by a pump, and is from the last apparatus returned in its warmed state to the lower reservoir US, where it replaces that withdrawn from below; the hot water

remains on top by stratification on the principle of displacement.

As soon as the temperature and pressure of the upper reservoir has dropped and that of the lower one correspondingly increased to the provided values, the discharge is completed. The purpose of the charging process which now begins is to return to the original starting condition.

For this purpose the water from the lower reservoir is led by the pipes to the evaporators V_1 to V_4 connected in series and evaporated by the diminution of pressure caused by the suction of the turbo-compressor K to the lower stages of which these are connected. This circulating water flows by itself as it comes from the top of the lower accumulator and enters a vacuum in the evaporators, the pressure in which gets lower and lower in successive stages. The maintenance of a water level in each of the evaporators is again assured by means of water seals whilst the total amount of water is regulated, dependent upon the compressor output, so as to keep the fixed temperature difference. A pump takes the water from the last evaporator and returns it, in its cooled state, to the bottom of the lower reservoir US.

Before entering this lower accumulator the water passes a heat exchanger W in which its temperature is further reduced by water from the cooling tower KT, or natural water if available; it is obviously necessary to withdraw the heat arising from the process losses, otherwise the mean temperatures of both accumulators would continually increase; by doing it at the point aforesaid the thermal efficiency may be increased as the average temperature of the lower reservoir for the discharging period becomes lower than that for charging.

Superheated steam leaves the compressor, being taken successively from the different outlets corresponding to the increasing back pressure. It then passes through the superheating accumulator ES, which generally will consist of a pressure vessel filled with iron, and where it is cooled by contact. After that the still somewhat superheated steam enters the upper storage reservoir OS. This completes the principal cycle.

Equipment Used

With regard to the different parts of the installation the following may be said: The upper reservoir is a simple hot water or steam container, which works essentially like that known as the Ruths storage. In general it will be expedient to select a pressure between 10 and 12½ atm. (140 to 175 lb.).

The superheat accumulator is in a certain way a particular feature of the plant which serves to improve its efficiency. The superheat is obtained from the compressor action by limiting the water cooling. The superheat is up to 300 or 350 deg. C. (572 to 662 deg. F.) or more, according to the body chosen to retain and thus store the heat. As a rule iron will be the most suitable body, it being subdivided in a way to give a large surface and hence a small drop of temperature between steam and itself; the steam passes one way during the charging period, leaving its superheat, and picks it up again when passing in the opposite direction in the discharging period. In the case unusually long storage periods are needed, the use of a special oil combined with a special heat exchanging apparatus may be more economical.

The lower reservoir is a large pressureless container which is alternately filled with hot and cold water by the displacement principle and is equipped with suitable distributing devices. In certain cases it may be more expedient to dispense with the lower reservoir vessel and make the basement in the foundations of the building serve as such.

Turbines are fundamentally of the type well known from the Ruths storage plants except for the outlet.

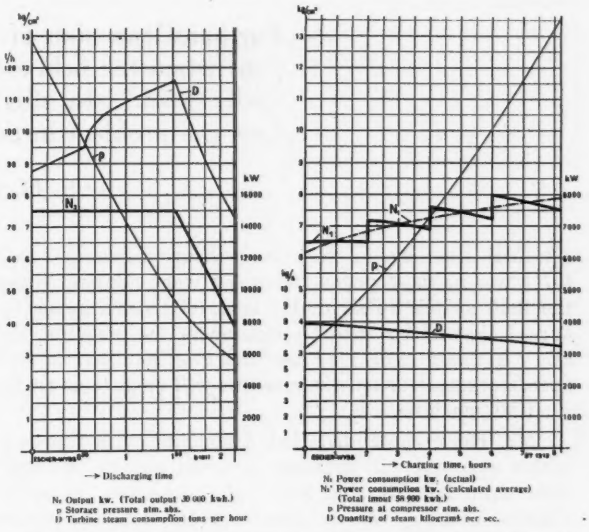

kW
D
p
N₁
Discharging time
Charging time, hours
N₁ Output kw. (Total output 30 000 kwh.)
p Storage pressure atm. abs.
D Turbine steam consumption tons per hour
N₁ Power consumption kw. (actual)
N₁' Power consumption kw. (calculated average)
(Total input 58 900 kwh.)
p Pressure at compressor atm. abs.
D Quantity of steam kilograms per sec.

FIG. 2. DIAGRAMS SHOWING CONDITIONS DURING DISCHARGING AND CHARGING PERIODS

Dependent upon the vacuum conditions chosen, these special types may be built in units of 15,000-20,000 kw. with single cylinders and considerably larger with two cylinders.

Efficiency and Cost

Efficiency depends in the first place on the qualities of the machines and further essentially on the selection of the thermo-dynamic conditions. To a certain degree an increase of efficiency can be attained with increasing plant costs. With average conditions of first cost a value of between 48 and 50 per cent is arrived at. This figure includes all losses with a single daily discharge at fairly constant load; these values will go down with varying load for peak service; but a value of 45 per cent may safely be expected even for unfavorable conditions.

Projects have been carefully worked out in every detail and costs ascertained so as to form a reliable basis for estimating. On the basis of Swiss prices and wages at the beginning of 1933. the price of a representative plant inclusive of building, with turbine units of about 15,000 kw. and with a full load discharge duration of 2 hr. or for a 4-hr. three-point peak-load discharge, costs, ready for service, without the cost of ground. about Swiss frs. 245. (about $67.50 at present rate of exchange) per kilowatt maximum output. The floor space required is about 0.08 to 0.1 square meters (0.86 to 1.08 sq. ft.) per kilowatt. For other discharge durations the costs are different, furthermore for installations having large units the specific costs are lower and on the contrary they are higher for installations with small units.

POWER PLANT ENGINEERING October 1933

The FIELD SWITCH *Opens Again*

Further Discussion of the question, "what happens when the field switch of a generator opens under load." In this article the author analyzes the problem in detail by means of vectors.

By E. H. STIVENDER

SOME time ago a very interesting discussion took place in these pages regarding what happens when the field switch opens under load. It seems generally agreed that under such circumstances the machine will carry at least some load but the question that is still open is whether or not the machine will operate as an induction machine.

Mr. Heise contended that a machine with the excitation removed will increase in speed and at the same time drop considerable load. Mr. Johnston, however, claimed that any loss in direct current magneto motive force is compensated for by a synchronous a. c. component supplied from other machines. Since this component rotates at the same speed as the d.c. m.m.f. formerly did, there would be no loss in resultant flux, provided the a.c. magnetizing ampere-turns across the air gap are equal to the former d.c. ampere-turns on the field poles. It was pointed out that, due to the drooping speed-load curve of any prime mover, any increase in power output must be accompanied by a decrease in frequency, and vice versa, within the range of the set speed regulation. Mr. Johnston has confirmed his original opinion in the December 1932 issue, that is, that if the machine continues to operate, there will be no shift of load due to loss of field excitation, and I also gather that he contends there will be no increase in speed. This means that the generator would have to operate as an hysteresis generator, which brings up the type of rotor under consideration.

I agree in part with both of these opinions, and since the discussion has gone this far into internal operating principles, it would apparently be well to give a more complete discussion and find more approximately what would be required in current for a machine to operate as an hysteresis (synchronous) generator, and as an induction generator; and whether a machine in parallel with it would be capable of furnishing this current without undue voltage drop and consequent loss of load to asynchronous motors and lighting loads, whose power inputs vary approximately with the square of the voltage applied.

First consider the general alternator diagram of Fig. 1, which can be found in any of the handbooks. The generator is carrying a load of I_1 at a power factor cos θ and terminal e.m.f. E_1. The armature ampere-turns A_1 are in phase with and proportional to I_1. Leakage reactance voltage I_1X_1 is leading I_1 by 90 deg; this when added to E_1 vectorially gives E_{a1}, which is approximately the induced e.m.f. in the armature. The a.c. resistance, being seldom more than 5 per cent of X, is ignored to simplify the problem. Then R_1 can be taken from the load saturation curve to be the resultant reluctance ampere-turns required to produced flux

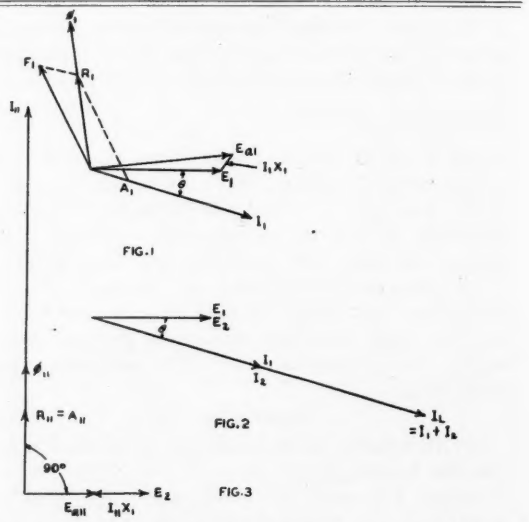


FIG. 1. General alternator diagram. A_1 = armature m.m.f. R_1 = resultant reluctance m.m.f. I_1 X_1 = leakage reactance e.m.f. F_1 = field m.m.f. ϕ_1 = flux. E_{a1} = total e.m.f. induced by ϕ_1. E_1 = terminal e.m.f. I_1 = armature current. Cos θ = power factor.

FIG. 2. Current and Voltage relations of two generators, 1 and 2, carrying equal loads at the same power factor. I_L is the total load current.

FIG. 3. Approximate current e.m.f., m.m.f. and flux relations of generator No. 1 running in parallel with zero field excitation and zero load but constant bus voltage.

Φ_1, which generates E_{a1}, and is in leading quadrature with it. R_1 is the resultant of two m.m.f. components F_1 and A_1, F_1 being the field m.m.f., proportional to the field current.

Suppose there were two such machines carrying the same load at the same power factor. This would be

represented as in Fig. 2, where $I_1 + I_2 = I_L$ =the load current. Now let the load be taken from No. 1 machine, that is I_1 disappears; A_1 and I_1X_1 also disappear, which would make $F_1 = R_1$ and in quadrature with E_1. Owing to the elimination of this m.m.f. and e.m.f., E_{a1} and E_1 would become the same vector and somewhat greater than formerly, if there were no automatic voltage regulation used. Let the field current be discontinued entirely; then the conditions for No. 1 machine approximate Fig. 3. $R_{11} = A_{11}$ replaces F_1, and is in quadrature with E_2; I_{11}, which must be in phase with A_{11}, will increase over its original value to a value somewhat greater than short circuit current due to saturation; X_1 remains nearly constant since it is leakage reactance and hence is not greatly affected by saturation; hence in order to avoid computations, we will say that I_{11} is equal to the short circuit current of the machine at no load excitation; that is, as much leading current must flow to create full field flux as lagging current to destroy it, at no load excitation.

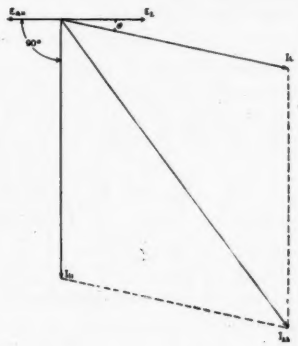


FIG. 4. Showing approximate current I_{22} required from generator No. 2 to supply the excitation current of No. 1 in addition to the total current.

Taking arbitrary values; say the inherent voltage regulation of the machine is 20 per cent, and has a saturation factor of 1.8; then the short circuit current at no load excitation would be about 1.1 times full load current. Let this equal I_{11} numerically, which will put the error on the lesser side, and if I_1 (Fig. 1) represents one-half full load current, then $I_{11} = I_1 \times 2 \times 1.1$ (about), and leads E_2 by 90 deg.

In Fig 4, $I_L = 2I_1$ represents the load current, and since the load was taken off of generator No. 1 and there are no other generators, I_L also equals I_2, the current of generator No. 2, when No. 1 had full field but no load, and No. 2 has automatic voltage regulation. Vector E_{a11}, which is generated by the flux of I_{11}, is less than E_2 due to the $I_{11}X_1$ drop, and has been rotated 180 deg. to establish its proper relation to E_2 in the common circuit. I_{11} now lags E_2 by 90 deg. If the load is not synchronous or anti-inductive, and over excited, machine No. 2 must furnish I_{11} and I_L; these added give I_{22} which is the current flowing in the windings of No. 2 with full voltage maintained and no load on No. 1.

Now since the voltage of No. 1 has been established, let more force be applied to the prime mover to make No. 1 take more load ($E_1I_{L1} \cos \beta$); this makes E_{a1} move counter-clockwise to a position E_{a1}' in Fig. 5, and the resultant of E_{a1}' and E_2 is momentarily established and marked E_R. The current I_{L1}, in lagging quadrature to E_R, flows to make $E_R = I_{L1} \times (X_{s1} + X_{s2})$ approximately, where X_{s1} and X_{s2} are the synchronous reactances of generators 1 and 2 respectively. Now both I_{11} and I_{L1} are flowing in generator No. 1 windings and they are added to make I_1, the total current in No. 1. Since I_{L1} is a function of E_2, it is added to I_{22} to make I_2', the new current of No. 2 when No. 1 takes on load. The load current I_L remains the same, if it is possible to maintain the voltage.

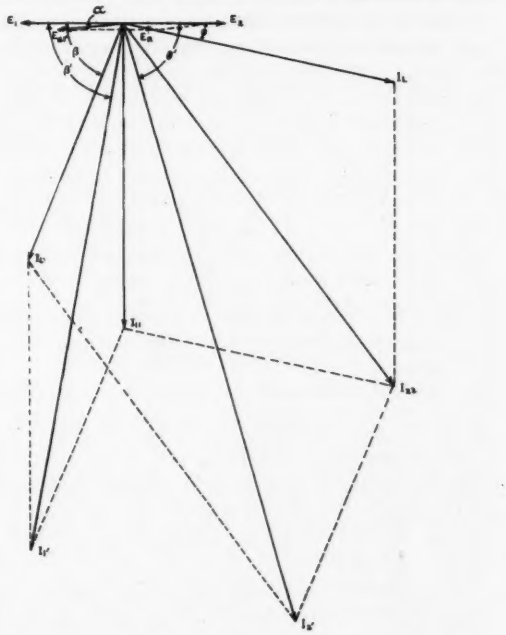


FIG. 5. Complete current and e.m.f. diagram of alternators 1 and 2 while sharing load I_L. When No. 1 picks up load I_{L1}, its total current is $I_{11} + I_{L1} = I_{1'}$. The current of No. 2 is increased from I_L to $I_{22} + I_{L1} = I_{2'}$. The load of No. 1 has increased from zero to $E_1 I_{L1} \cos B$ or $E_1 I_{1'} \cos B'$. That of No. 2 has decreased from $E_2 I_L \cos \theta$ to $E_2 I_{2'} \cos \theta'$. The coupling angle has increased from zero to α.

It is to be kept in mind that these vectors and phase angles are only approximations; it being assumed that it is possible for the voltage E_2 to be maintained constant with an automatic voltage regulator. Also the additional armature reaction ampere-turns, IR drop, leakage reactance e.m.f., and changing saturation in machine No. 1 when it picks up load, affect the values shown by tending to decrease E_{a1}' and increase I_{11}; this calls for more field excitation in No. 2. The writer believes it will be agreed that the conditions shown in Fig. 5 are an impossibility, owing to the currents reaching around twice short circuit current when No. 1 takes one-half full load kw. and No. 2 takes full load.

The field windings of No. 2 will not ordinarily carry the required heavy currents very long, even if the exciter ceiling voltage is high enough, which is very doubtful; therefore in order to approximate these conditions, there must be more apparatus in parallel with No. 1 to furnish the required magnetizing current.

If we try to pick up more load with No. 1, its current I_1' increases considerably and reaches a more prohibitive value, causing great I^2R loss, mechanical stress and a further reduction in E_{a1}' requiring it to swing by a greater angle counter-clockwise than corresponds to the additional load. This being apparent from the fact that the load is a function of E_{a1}' and the sine of the coupling angle, as shown in Fig. 6. When α reaches 90 deg., the machine is unstable and any further slight increase in force from the prime mover causes a greatly increased angle and less delivered power.

Power is torque times speed; since it is power output considered here, the torque is negative; it depends upon the resultant flux across the air gap, which is the same as saying it depends upon E_{a1}' as above. Therefore, owing to this decrease in negative torque (restraining torque), the machine pulls out of step if it is required to take on more than a given amount of load, which is less than full load kw. and is determined by various factors such as line impedance, synchronous impedance of all machines in parallel, field excitation of other machines, saturation factors, reluctance between pole pieces of the unexcited machine, etc.

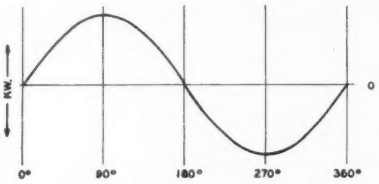


FIG. 6. Power present in a generator circuit during one complete slip cycle, when the machine has d.c. field excitation.

If the machine is salient pole, other factors being equal, it will carry more load without pulling out of step than a round rotor (turbo) generator, which is apparent from the greater reluctance between poles making the hysteresis characteristic more prominent. Likewise since the round rotor is seldom laminated, while the salient poles are, the turbo will carry more load as an induction generator than will a slow speed (salient pole) machine for the same slip. The handicap of the longer air gap of the turbo as compared to the slow speed machine is greatly offset by the greater reluctance between poles of the latter.

When a salient pole machine pulls out of step and runs as an induction generator, the load carried will pulsate, as indicated by Fig. 6; in fact if the distance between pole pieces is great, there may be zero power output during parts of the slip, or coupling angle, cycle. Of course when there is no field excitation, Fig. 6 is not correct for a machine running over synchronous speed, since the only negative power (power input) possible would be the I^2R loss.

Owing to the large air gap and resistance in the rotor of a synchronous generator when run as an induction machine (except when amartisseur windings are used) the magnetizing current is excessive and the efficiency extremely low; hence in order to deliver much power, the negative slip would have to be greater than that allowed by the governor, even when the setting is for full load. This is especially apparent from the drooping speed-load characteristic mentioned before, which would not permit more load to be carried at a higher speed.

It would be difficult to construct a circle diagram for a synchronous machine running in parallel over synchronous speed, since in the case of a salient pole machine, the reluctance is not constant; and the rotor resistance would be only a rough estimate for either type of rotor.

It is apparent, however, that it is possible for a synchronous machine to pull out of step and run as an induction generator when the proper conditions prevail, and such conditions would not be unusual. Also it would not be extraordinary if the machine stays in step and carries less than full load. Damage to the rotor is also possible if the slip is very great and the machine is run very long. Re-synchronizing by re-application of full field current is possible, the resulting increase or decrease of armature current depending upon at what part of the slip cycle the rotor is when the field switch is closed. If the machine is not out of step, no increase of armature current can occur by simply closing the field switch; this can be ascertained by watching the field ammeter for a low frequency alternating current in the discharge circuit, if it is present the machine is out of step. There can be an enormous increase of current if the machine is out of step when the field is applied.

Sodium Vapor Highway Light

THE SODIUM VAPOR lamp has been given its American premiere at Schenectady, where a half mile of highway has been illuminated, under the joint sponsorship of the General Electric Company and the New York Power and Light Corp. Twenty-two lighting units have been placed, so installed that they can be shown in spacing combinations of 125, 250 and 500 ft. for purposes of comparison.

Perhaps the most important advantage of sodium vapor lamps is their comparatively high efficiency. They can be manufactured with two to three times the efficiency of the tungsten filament incandescent lamp, and there are indications that even greater efficiencies will be obtained eventually. The arc in these lamps has the appearance of a neon discharge, somewhat red in color, when the current is turned on. As the lamp is warmed by its heater element, and the arc and the pressure of the sodium increases, the light becomes yellow. At first glance the light from the new lamps seems markedly dim in comparison with incandescent or arc lamps, but seeing is actually made easier by the reduced glare and the monochromatic quality of the light. Sodium lamps for the same wattage input give about 2½ times the light output of the incandescent lamp.

The lamp itself is a gaseous discharge device, mounted within a "thermos bottle" to conserve heat and maintain the sodium at about 480 deg. F. It is 7 in. long and less than 3 in. in diameter, and fits closely within the "thermos" globe. The arc current is carried through the lamp by the gas itself instead of by a filament. The lamp wattage is about 80 to 90 watts and the light output about 4000 lumens, equivalent to the 400-candlepower Mazda Lamp which consumes 215 watts.

Does Engine Maintenance by Unskilled Labor Pay?

By J. J. McDougall

DIESEL ENGINE maintenance is a matter of vital interest to mechanics, operators, owners and manufacturers. Thousands of skilled mechanics are out of work, many of whom have been laid off and unskilled men given their jobs in order to save a few dollars. Poor maintenance work is endangering the operating record of operators, the investment of owner and the reputations of engines and manufacturers.

These conditions exist in many plants. In two plants two engines were almost completely wrecked, in another $20,000 was spent trying to overhaul an engine that could have been repaired for less than $2000, or which could have been replaced for about $15,000. With such glaring examples it is hard to understand why unskilled labor is preferred. The following example is typical of a large number of plants using unskilled labor.

For the first few weeks after the engine was put in service the performance was good except that the cooling water temperature soon began to rise gradually. This was blamed on the cooling tower, which was said to be not over half large enough in spite of the fact that the load on the engine reached full rating only when the hoist was running, the average load being about 33 per cent rating.

Manufacturers recommendations regarding overhauling and lubricating oil conditioning were followed out to the extent that could be expected from unskilled labor. After 18 mo. service the engine could only be started with great difficulty by preheating the inlet air and raising the starting air pressure, in fact for the last 12 mo. of this period the engine was not delivering satisfactory service. Later due to a change in required service, that of pumping the mine out once a week with an occasional run of three or four days, the engine was practically useless, because after standing for six days in about freezing temperature, it took so long to get the engine started and cost so much to operate it that it was much cheaper to run the standby gasoline engine.

An examination of the engine (a 300 hp., 6-cyl., 4-cycle solid injection Diesel of which the design, workmanship and materials is excellent) showed that two of the three starting valves were inoperative and that some of the exhaust and inlet valves lacked over 50 deg. of their proper opening, their timing being out accordingly. The fuel injection was from 5 to 16 deg. too late, and the only injection nozzles in proper condition were three new ones bought to replace supposed wornout ones which lacked only a little skilled attention.

Incorrect valve settings were due to the cam-shaft bearings being badly worn from lack of lubrication caused by oil holes which were plugged with wicking supposed to feed the oil from the wells but which in reality prevented it. The only oil the bearings received was that which dribbled along the shaft from the cams. The cam-shaft thus gradually dropped down throwing all the valve settings out, conditions finally getting so bad that under some conditions the exhaust temperatures varied from 200 to 1000 deg. F.

When the bearings were fixed up and the proper clearances given to the various push rods and valve tappets, the engine started from dead cold with 200 lb. less starting air pressure and was now good enough for the service required although far from being correct.

The engine was then opened up, and the lubrication system was found in deplorable condition, the interior of the engine being covered with a coat of heavy black sticky muck, difficult to remove even with scrapers. This condition was due to the old oil being drained out and the new dumped in, no cleaning or flushing being done and the filter entirely neglected. Soon after starting up the engine the oil became hot despite a good oil cooler and the oil being in such thinned condition it drained off all surfaces even off the muck, a few minutes after shutting down giving them a dry appearance instead of the normal oily one. Frequent oil changes under such conditions explains the high consumption of lubricating oil.

Piston Rings Chipped Out

As the pistons are entirely lubricated from the oil thrown on them by the cranks, they also were in filthy condition, the oil control rings and at least half the power rings being stuck, the top two of all pistons having to be chipped out. The piston heads and trunks were heavily carbonized as were the cylinder heads and valves. The pistons were very close to the seizure point being blue in color in many places. The crank-shaft bearings had started to wear and had the shaft so much out of alignment that the flywheel was beginning to wobble, this condition if allowed to exist would eventually break the shaft.

Valves, due to the excessive roller or tappet clearances, had beaten into the heads by as much as ⅛ in., requiring that both valves and heads be reseated. After properly reconditioning the above neglected parts as well as the fuel pumps and filters and the governor, the engine started promptly with a starting air pressure 300 lb. less than generally used when in supposed good condition; and after three months of variable service, it shows that the lubricating cost is about ⅓ and the fuel cost ⅔ of that during its last 12 mo. service.

In this isolated plant (80 miles from the railroad), in the mountains over rough roads) where fuel costs $0.13 per gal. and lubricating oil $0.75 per gal., this means a saving of at least $2500 a year of normal service (24 hr. a day, 28 days a month); the saving in other departments due to having plenty of reliable power is also considerable.

Now there is very little oil fog, the lubricating oil never gets hot and instead of the cooling tower not being large enough, it is bypassed entirely on light loads. Further, all other power machinery, such as hoists, gasoline engines, air compressors and motors can be expected to be found in similar condition as the engine was, thus wasting more money, so that the entire waste far exceeds the slight cost of hiring a skilled mechanic.

The above is not an isolated example but is typical of dozens of plants whose owners prefer hiring cheap unskilled labor and charge off the excessive unnecessary maintenance and cost of supplies as necessary operating expenses.

POWER PLANT ENGINEERING October 1933

Turbines Replaced by Engines

By Benj. H. Bonnar, General Superintendant, Lasalle & Koch Co., Toledo, O.

ABOUT FIFTEEN YEARS ago the new Lasalle & Koch Co. department store building was completed with a power plant consisting of three 175 lb., 100 deg. F. superheat Springfield boilers fired by Taylor stokers and four 250-kw.; 250 v. direct current; 1200 r.p.m. geared turbo-generator units. Later a 500-hp. Erie City boiler was added.

Both the steam and electric load continued to grow and in addition to a lighting, elevator and other power load of around 3000 amp. the company built up a considerable steam heating business which now has about 80 customers in four blocks. The store electric load in winter runs around 6500 kw. hr. per day and around Christmas it runs up to a peak of 7000.

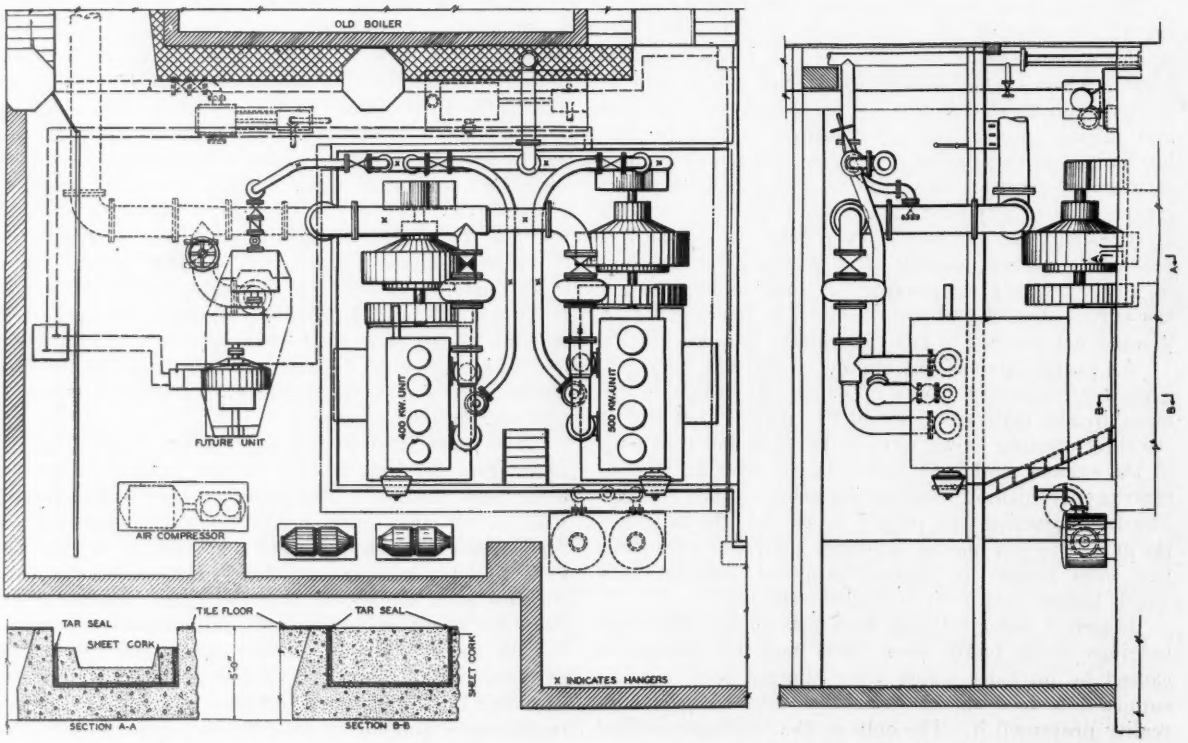
The steam flow is completely metered and as of recent years the water rates on the old turbines became so high that even with the large use for exhaust steam it was uneconomical to generate the entire load. The advisability of replacing them with more efficient prime movers was then considered. Because of the heavy steam load it was felt that with proper equipment purchased power, which had been used to augment the generated power supply, could be eliminated.

After the studies were completed, a contract was given to The Jos. L. Skeldon Engineering Co. to replace three of the turbine units with two Ames vertical uniflow engines, leaving one of the turbines in place for standby service. This space, now occupied by the turbine unit may be used for a third engine unit to be installed later.

Both space and time were at a premium. The turbines were installed on a balcony just below the steam drum level of the boilers. In order to get sufficient head room for the engines it was necessary to install them on the boiler room floor level and cut through the balcony floor leaving the cylinders project up above the balcony floor. One of the new units is a 4 cyl., 14 by 18 in. engine driving a 2000 amp., 250 v. (500 kw.) Crocker Wheeler generator and the other is a 4 cyl., 14 by 16 in. engine driving a 1600 amp., 250 v. (400 kw.) generator of the same make. Foundations of both engines are cast in one slab, insulated for vibration with Vibracork as shown in the drawing. All piping has been covered with 1 in. of Mineral Felt, ½ in. of Minfelt cement and Muslin painted with a flat paint. Since these changes the temperature of the engine room has been lowered about 13 deg. F.

Following the completion of the plant, complete tests were run by S. F. Davies of Kaiser, Muller & Davies of New York and John J. Cogan, Management Councillor of R. H. Macy & Co. Tests on full and overload showed temperature rises of both generators to be well under the 40 and 50 deg. C. rise guaranteed. Full load water rate tests on the 500 kw. engine showed 29.6 lb. of steam per kilowatt hour with 173 lb., 46 deg. F. superheat and 4.5 lb. back pressure.

This was well under the guarantee of 29.7 lb. per kw-hr. based upon full load with 175 lb., 100 deg. F. superheat and 5 lb. back pressure. Allowing corrections for variation of steam conditions from those of the contract would increase the guarantee to 31.5 lb. per kw-hr. so that the actual test ran about 2 lb. per kw-hr. better than guaranteed.



ARRANGEMENT OF ENGINE GENERATORS AND AUXILIARIES IN LASALLE & KOCH DEPARTMENT STORE

Keeping Down Industrial Power Costs

Since 1904 the Security Mutual Insurance Co., Binghamton, N. Y., Has Been in Continuous Service and Is Still Able to Show a Savings of $3,500 a Year Over Purchased Power

NEARLY THIRTY YEARS ago, in 1904, Asa P. Hyde, then chief engineer of the Binghamton Chair Co., left his position to become chief engineer of the Security Mutual Life Insurance Co. at Binghamton, N. Y. He installed the new power plant and operated it until last fall when he retired, turning the responsibility over to his son, Jess.

In addition to supplying complete light and power services to its own building, electric power and steam

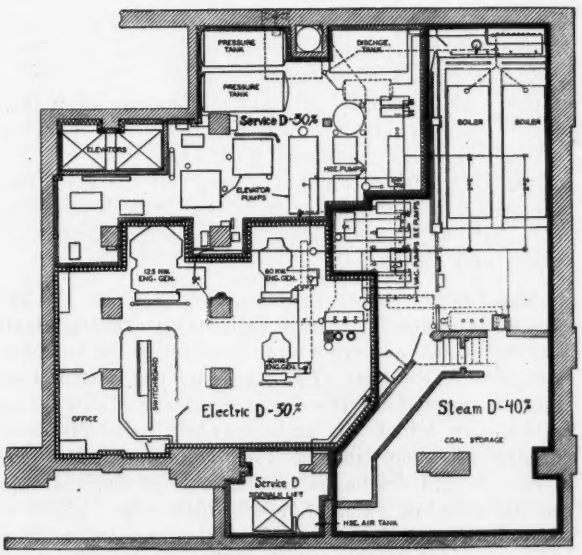


FIG. 1. PLAN OF THE PLANT

are sold to a number of customers in the block. The equipment and plant remain practically as installed and the care which it has received over these years is shown by the fact that the h.r.t. boilers are still allowed by the state inspector to carry their original pressure.

Last year the plant and its operation were the subject of an investigation and report by an outside consulting engineer, M. Riewerts of Binghamton, N. Y. The object of the investigation was to determine whether the existing plant was able to compete with purchased power and to lower operating costs.

The conclusion was that, based on 435,575 kw-hr. and 172 kw. demand, any changeover would result in a purchased power cost of $10,105 as against the actual cost of $6,609. The savings of $3,496 together with certain fuel savings and recommended equipment changes was considered more than enough to justify continued operation of the plant. In this investigation the total power cost of energy plus demand charges was calculated from the schedule as $0.0232 per kw-hr.

Total operating cost of the plant and allied services for three years are given in Table I. At the time a rice coal costing $1.85 per t. at the mine and $5.20 delivered was being mixed with a bituminous coal costing $6.00 per t. delivered in the proportion of 85 and 15 per cent. As fired, the heating value was about 12,895 B.t.u. per lb. The rice coal has since been reduced to $4.66 per t., resulting in approximately $1000 a year total saving.

The plant was quite completely described in an article on page 708 of the June 15, 1929, issue of POWER PLANT ENGINEERING. Briefly, it consists of two 80-in. dia., 20-ft. long h.r.t. hand-fired boilers, a 40, 60 and 125-kw., 110-v. d.c. engine generator sets, 2 hydraulic elevators and the necessary pumps and auxiliary equipment. With the exception of the 60 kw. unit which replaced a smaller engine several years ago, all major equipment was installed when the plant was built.

For the purpose of the investigation the plant was divided into the steam, electric and service departments as indicated on the plan, Fig. 1. Original equipment costs were: steam plant, $8.755; electric plant, $17,090; service department, $20,515, or a total of $46,360. Present worth of the equipment based on present service and probable life extension (mostly taken as 10 yr.) were placed as: steam plant, $3,996; electric plant, $6,470; service department, $8,970, or a total of $19,436. In this the elevators and elevator pumps represented an original investment of about $19,000 and an estimated present worth of $8,000.

Recently replacement of the old hydraulic elevators was considered. The estimated cost for modern motor driven equipment was about $47,000 which with construction costs would have brought the total to almost $65,000. Tests of the present elevators (10 story build-

ing) showed 236 trips required 75 kw-hr. or 6.8 kw-hr. per mile. Records over two months showed 7.29 kw-hr. per mile representing a cost of about 11.6 c. a mile. Under the circumstances the change was not made, although the installation of a third shaft to improve traffic conditions is still under consideration.

In order to arrive at the proper division of coal for power and steam accounting purposes, two methods were used. The total contents heated amounted to 1,813,000 cu. ft. which, based on 2.4 B.t.u. per cu. ft. per hour and a heating season of 5,040 hr., amounted to 1010 t. of coal for heating only. Actual tests, using one boiler on the heating system and one boiler on the electric system, checked these calculated figures closely. The 1717 t. of coal for 1931 was, therefore, charged 1010 t. for heating and 707 t. for power generation.

TABLE I. OPERATING COSTS FOR THREE YEARS

	1929	1930	1931
Payroll			
Engineers and Firemen	$11,688.63	$11,699.10	$11,976.48
Elevators	3,271.73	3,265.88	3,417.50
Janitors	7,860.67	7,778.00	7,650.00
Watchman	1,582.50	1,614.17	1,591.00
Extras	100.20	40.50	.....
Commission	1,956.74	1,963.54	1,742.73
Window Cleaners	650.00	657.00	669.80
Window Shades	201.21	112.12	278.64
Insurance	3,475.94	2,145.20	2,218.23
Coal	8,732.06	8,565.63	8,442.96
Carting (Coal and Ashes)	1,550.98	1,390.86	1,389.78
Oil	256.32	133.65	216.26
Gas	57.53	64.86	113.76
Water and Blvd. Lights	645.73	487.57	400.72
Elec. Sup. and Repairs			
Bldg.	1,322.56	1,399.63	1,400.06
Elev.	11.89	58.50	7.65
General Expense			
Bldg.	47.63	840.43	2,265.92
Engines	2,336.80	2,300.16	1,883.64
Elevators	158.54	622.41	1,717.62
Janitors	791.80	1,050.37	1,328.10
Toilets	692.61	618.04	91.47
Paint and Painting	2,620.88	1,857.89	2,184.55
Lumber and Carpenter	720.64	699.56	408.70
Plastering	.....	7.50	96.45
Plumbing	266.08	522.04	204.64
Roof	.....	435.62	60.00
Miscellaneous	585.98	4,791.15	1,436.45
	$51,587.65	$55,111.78	$53,193.11
Credits	1,353.78	301.38	165.18
	$50,233.87	$54,810.47	$53,027.93

The payroll of $11.969 was divided 60 per cent to the steam, 20 per cent to the electric and 20 per cent to the service department. Supplies and repairs were considered item by item and the total of $1,605 divided: steam, $1,013; electric, $442; building maintenance, $150. This gave a total cost amounting to $0.77 per thousand pounds of steam and $0.0152 per kw-hr. Making an allowance for hot water and miscellaneous live steam used gave a balance of 15,930,000 lb. of steam to the heating system consisting of 23,552 sq. ft. This amounts to 677 lb. per sq. ft. or a steam cost of about $0.51 per sq. ft. of radiation.

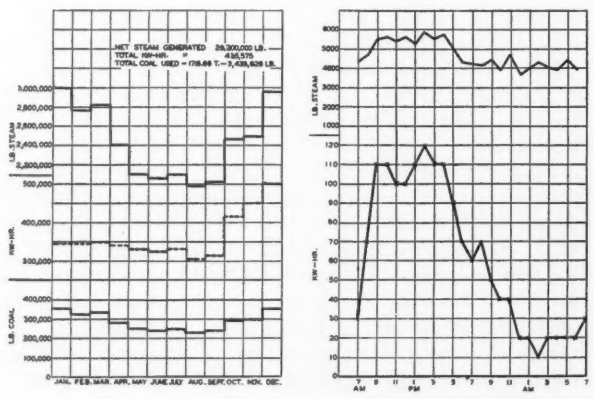


FIG. 2. TYPICAL YEARLY AND DAILY LOAD CURVES

A comparison of generated and purchased power showed a saving of $3,496 annually as explained above. Steam, electric and coal consumption by months for 1931 and a typical steam and power load curve by hours are shown by Fig. 2.

Today the appearance of the power plant belies its 30 years of service. Equipment is all in first class condition, paint new and bright, nickel plated fittings on the engines as neat and trim as when new and by special authority of the state boiler inspector the boilers are still operated at their original pressure. This is indeed an enviable record of accomplishment which has seldom if ever been duplicated.

The Drumm Storage Battery

AN IMPORTANT technical development of note in the traction field, at least, is the development of a new traction battery, the invention of Professor Drumm of University College, Dublin, Ireland. This is an alkaline cell, in which, as in other alkaline batteries, nickel oxides are used for the positive plates. The special feature of this cell is that the negative plates consist of nickel gauze grids, and the electrolyte is a solution of zinc oxide in potash. On being charged the nickel grids become coated with metallic zinc. The voltage of this combination is substantially higher than that of the ordinary alkaline cell *viz.* about 1.86 v. when fully charged, as compared with about 1.34 v. This in itself is an important advantage, but the chief feature which is claimed for it is that very heavy currents can be passed through the cell during both charge and discharge.

The battery as at present made consists of 264 cells with a capacity after a full charge (taking about 4 hours) of 600 ampere-hours. In practice the capacity is related to the time of charge, and the normal routine, as adopted on the Great Southern Railways of Ireland, on which an experimental train has been running for some time between Dublin and Bray, is to charge and discharge the battery 20 times a day. the duration of each charge, which takes place at the end of each journey, being 20 min. Under these circumstances the input on each occasion is about 150 ampere-hours; the average voltage per cell on charge is 2.03 and on discharge 1.65, and the average overall efficiency under service conditions about 75 per cent. The weight of each cell is 112 lb. Thus the output per cell corresponding to a 20-min. charge is a 2 watt-hours per pound. During discharge the current can, when required for accelerating the train, be raised to 1,000 amp. without injury to the battery. Reliable information as to the capital and maintenance costs is not yet available, but the makers claim that a life of several years in regular service should be obtained. —"The Journal of the Institution of Electrical Engineers."

Requirements Demanded of Industrial Cooling Water

Methods of Testing and Types of Treatment Used to Prepare Water for Use in Water Jackets and Process Coolers. By John W. Romig

BESIDES BOILER and power plant uses for water, industry uses quantities of water for processes and for various cooling applications. Much discussion has been given to water used for processes, and that used for power, but the other application for indirect cooling deserves consideration, as little thought is given this service in many plants. Cooling may be done in pipes or through walls of water jackets or external to a vat by means of a jacket arrangement.

Considering water jackets, applied to critical portions of furnaces, water cooled members of gas producers, process coolers and the like, general usage of untreated water is customary. Many operators merely turn on enough water to have a cool or cold stream flow from the overflow while others, particularly if water costs are high, may use high overflow temperatures.

While overflow water temperatures may show something of the efficiency of cooling with a given flow it must be recognized that scale in a water jacket will insulate the water space and cooling water will not be effective. Then too, the overflow temperature may, in a poorly designed water jacket, be a mixture of a relatively large flow of water through the jacket space and a small amount of very hot water from the surfaces. This condition can be remedied by design involving the use of baffles and a minimum volume for the job. A water jacket having a 1 in. space inside is as effective if baffled as one with a 6 in. space provided that scale, sludge and foreign matter are kept out.

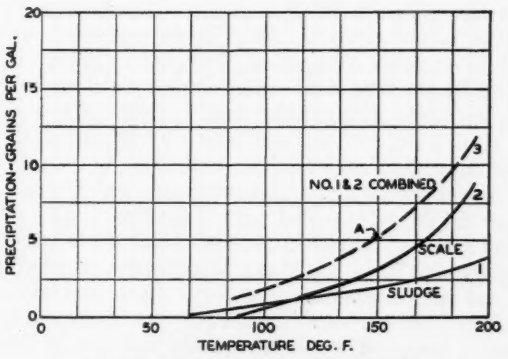
Sludge and Scale Formation

With a water used in cooling members, two factors must be given consideration. They are sludge formation and scale formation. Sludges have a tendency to precipitate and accumulate in the lowest extremity of a water space, the walls of which are exposed to heat. Scale may or may not form on the hot sides, depending on the water and temperatures. Sludge accumulations may be removed by flushing and it is advisable to have an accessible drain located at the low part of a water jacket for sludge removal if the water carries solids in suspension.

Scale formation depends upon the composition of impurities suspended in the water which change their form when the water is heated. Some waters will start scaling at lower temperatures than others, depending upon the quantities and nature of the impurities in solution.

By a study of a water the scaling or sludge forming characteristics may be determined with little effort. Of course, complete water analyses give the complete story of all of the impurities but a study of precipitation at varying temperatures gives a better guide for the operating departments. Data may be obtained with simple laboratory equipment on the precipitation tendencies of the impurities and by varying the temperatures and weighing precipitate a general curve may be developed. The procedure requires a generous sample of the water, measuring or weighing equipment, beakers, bunsen burner and screen, and filter paper.

The first step in the precipitation study is to filter a part of the sample saved separate when collected. The solids filtered from such a sample at room temperature gives a starting point for the curve. By taking additional portions of the simultaneously collected samples (a sample) and heating each to a definite temperature and holding each at that temperature for the same time precipitation for each temperature is determined. Analysis of the precipitate will show whether it is of a scaling or sludging nature. Upon completion of the work a curve or set of curves may be plotted. The accompanying chart shows the general outline of a set of curves.



WATER PRECIPITATION CURVES

Curves Indicate Danger Point

From the curves one can see about where the danger point is for the water in question. The sludge may be found to be a fairly constant quantity regardless of temperature but the scaling precipitates are likely to increase much more rapidly as the temperature approaches the boiling point. Using the curves shown one is immediately informed that sludge disposal provision, either by flowing out or flushing, is desirable in a jacket or cooler. An inspection of the scaling precipitate curve shows that scaling becomes

more and more a problem with temperature increase. By selecting a temperature of water corresponding to that of point (A), at the beginning of the sharp rise, one is able to utilize the water to the best advantage.

Exceptions might exist in case of waters quite free from scaling materials or sludges—such waters as are commonly found along the Atlantic Coast of the United States. With such waters there is little chance of serious scaling and sludge troubles are not common. With relatively scale and sludge free waters, the total precipitate becomes a matter of, say, 8 to 10 grains per gallon or even less and water jacket troubles are practically non-existent. As the impurities increase to 15 to 25 grains per gallon troubles increase, but when the content becomes 35 grains per gallon and upward, scale and sludge deposits become more of a problem. Just where a safe dividing line exists is dependent upon the constituents of the particular water. With a water, however, having over 15 grains per gallon of scaling and sludging material that will deposit at a certain temperature the water temperature should not greatly exceed that at which 15 grains per gallon precipitate.

Soluble Minerals Not Objectionable

Waters contain, besides scaling and sludge ingredients, soluble minerals. The soluble minerals that do not precipitate have little or no effect on cooling members because such constituents do not fill up sections of a water chamber nor do they form insulating films on heated surfaces. The effect of sludge is mainly that of clogging or filling up water space; however, when a sludge mixes with scaling material the sludge acts as an insulator and reduces cooling efficiency, thereby hastening the time when parts will fail.

Layers of sludge of a rather soft nature have been observed in water cooled parts bound with scale formed from scaling ingredients. The principal scale forming impurities in water are bicarbonates and sulphates of calcium, magnesium and iron. These materials may be removed by water treatment but such treatment, when a large water flow is required, may not be justified on an economical basis. As a partial correction proper design of water cooled devices and a study of the water applied in practice offers a compromise that will generally be satisfactory.

In the case of extremely hard waters it may prove advisable to consider softening equipment even though large quantities of water are used. For waters having a high bicarbonate hardness and free CO_2, aeration, addition of lime and settling is usually sufficient to make the water usable industrially, but for boilers additional treatment is usually required. The reactions for bicarbonate waters are as follows:

When lime, CaO, is added:

$CaO + H_2O = Ca(OH)_2$.

Free carbon dioxide — $H_2CO_3 + Ca(OH)_2 = 2H_2O + CaCO_3$.

Calcium bicarbonate — $Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O$.

Magnesium bicarbonate — $Mg(HCO_3)_2 + 2Ca(OH)_2 = Mg(OH)_2 + 2CaCO_3 + 2H_2O$.

Iron bicarbonate — $FeH_2(CO_3)_2 + Ca(OH)_2 = FeCO_3 + CaCO_3 + 2H_2O$.

After adding lime and settling, the solid matter precipitates as a sludge. If too little settling time is allowed this sludge may carry over into a water distribution system and cause trouble. The carbonate hardness above discussed is often called temporary hardness and upon boiling in the absence of sulphates forms only a sludge. The bicarbonates are stable while cold but decompose upon heating. While this group forms only sludge it practically is a scale when there are scaling ingredients in the water.

Treatment for Sulphate Group

Permanent hardness includes the scale forming sulphates which may appear with or without quantities of bicarbonates. The usual treatment of the sulphate group is to add soda ash, Na_2CO_3. The reactions with soda ash are:

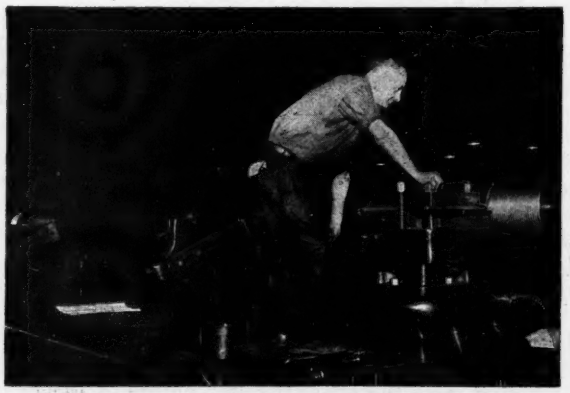
$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$
$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$

When magnesium salts are present the $MgCO_3$ must be precipitated as $Mg(OH)_2$ and lime must be added in addition to the soda ash to eliminate the magnesium hardness.

Alumina is frequently added as alum $Al_2(SO_4)_3$ to form an aluminum compound that will help with the precipitation and generally improve the clarity of the water. Alum also acts on iron hydroxide changing it to red ferric hydroxide. The aluminum hydroxide formed by the alum is called a "coagulant" because it aids in precipitation of solids in the water. In some cases alum alone has been used for water treatment.

Should difficulties encountered with water used for industrial purposes cause excessive trouble, water engineers or chemists should be called upon to give assistance in working out an economical solution. Firms marketing water treating equipment are usually in a position to give assistance in the study of water problems. There is such a thing as carrying water treatment too far in the case of industrial water, thereby incurring needless expense for equipment and materials. Decisions must be based upon design, a study of precipitation characteristics of the water and the economics of the use of a water having a lesser quantity of troublesome ingredients.

THIS 310-IN. CENTER through bolt, the biggest of its sort ever made, will help hold together the 60-in. diameter metal disks which compose the rotor for Philadelphia



Electric Co.'s new 250,000-hp. (based on delivery full generator rating at 100 per cent power factor) turbo generator now being built in the Westinghouse Works.

Double-Pipe Ammonia Condensers

IN PRESENTATION of this subject, the authors, W. S. Douglas and J. S. Westcott, called attention to the advantage of the double-pipe condenser, with inner water pipe and outer refrigerant pipe, as giving efficient transmission of heat and small size which offsets the complexity of structure. Past practice has designed on the basis of 10 sq. ft. of external surface of water pipe per ton of refrigeration but tests have shown wide variation of the coefficient of heat transmission with varying velocity of cooling water through the pipes. It is desirable to use as small surface as possible to keep down first cost.

Relation of Length to Diameter

Using K to denote the B.t.u. transmitted per hour per degree F. temperature difference and V to denote velocity of water in ft. per min., results of tests by the authors are expressed as:

$$K = 12\sqrt{V} \quad (1); \text{ or } K = 28\sqrt[4]{V} \quad (2)$$

For a given duty, the first expression works out to a certain length of pipe, regardless of diameter since, if pipe diameter be halved, surface will be halved but cross section for flow will be quartered and velocity of water for a fixed amount passed will be quadrupled. Since K varies as $\sqrt{V}$, it will be doubled, which balances reduction in area, so heat transmitted will remain the same.

If heat transmitted per hour in B.t.u. is H,—temperature difference in deg. F. is T,—water volume in cu. ft. per hr. is Q,—internal pipe diameter in inches is d,—and external diameter D,

$$H = K\,T\,L \times 3.1416\,D \div 12$$

$$L = 12\,H \div (3.1416\,T\,D\,K) = 12\,H \div (3.1416\,TD \times 12\sqrt{V})$$

But

$$V = \frac{Q}{60} \div 3.1416\frac{d2}{144} \times \tfrac{1}{4} \qquad (3)$$

and substituting this value for V gives:

$$L = \frac{Hd\sqrt{3.1416}}{3.1416\,T\,D \times \sqrt{Q}}$$

If H, T and Q are constant, this works out that L is constant, since d and D in numerator and denominator practically cancel. The diameter of pipe can be chosen to give the friction head allowable.

For water velocities up to 160 ft. per min., expression (1) for K gives safer values; for higher velocities, expression (2) is better. Pipe under ½ in. diam. is not practical and low velocities are usually used with small diameter pipe, hence expression (1) has been used in working out L up to ¾ in. diam. and expression (2) for larger sizes.

*From a paper before the Inst. Mech. Engrs., Great Britain.

Determination of Length Needed

In working out values for L, assumptions were made as follows: 12,000 B.t.u. per hr. in the evaporator and 15,600 in the condenser per 1 t. refrigeration, temperature of evaporation being 15 deg. F.; 15 deg. temperature rise of cooling water and 12 deg. logarithmic mean temperature difference between refrigerant gas and water; maximum water velocity, 300 ft. per min.

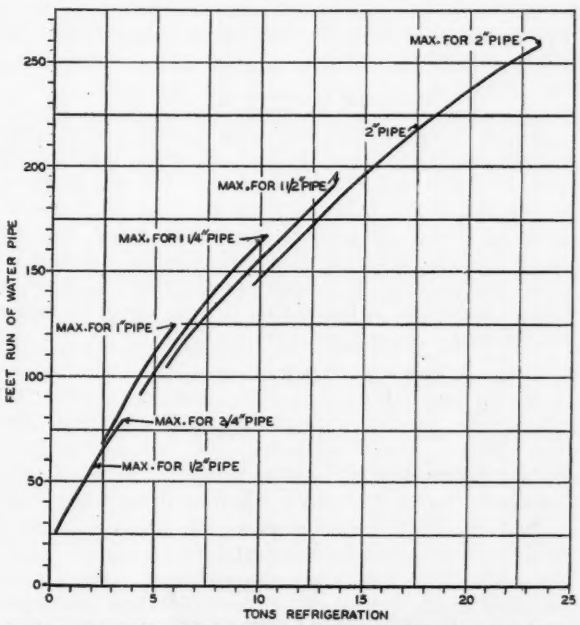


FIG. 1. LENGTH OF WATER PIPE NEEDED IN AMMONIA CONDENSERS FOR EVAPORATION AT 15 DEG. F., 15,600 B.T.U. IN CONDENSER PER TON REFRIGERATION

H will be tons refrigeration times 15,600. $Q = H \div (15 \times 62.4)$.

Then assuming a value for d by equation (3), compute V, which must not be over 300 ft. per min. If V is too large, choose a larger pipe diameter.

Cooling surface in sq. ft., A, $= H \div (KT)$, K being from equation (1) for ¾-in. pipe or smaller, from (2) for larger diameters.

$$L = A \div (3.1416\,D \div 12) = 12\,A \div (3.1416\,D)$$

By this method a series of curves for standard pipe was worked out as in Fig. 1, the curve for pipe under ¾-in. being continuous, since by equation (1) L is independent of diameter, but curves for larger diameters where K is from equation (2) being discontinuous.

Maximum length for any size pipe is where V becomes 300 ft. per min. as figured from equation (3). The curves are for evaporation of refrigerant at 15 deg. For other temperatures, curves can be worked out using

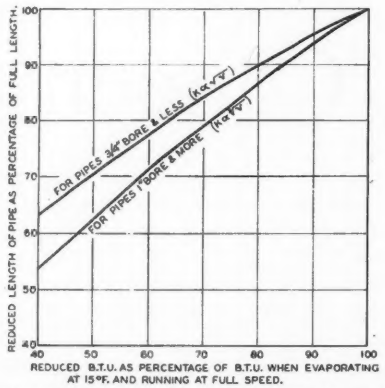


FIG. 2. REDUCTION IN PIPE LENGTH FOR AMMONIA CONDENSERS AT LOW CAPACITIES

proper values of heat for evaporator and condenser for 1 t. refrigeration.

Pipe for Reduced Capacity

If the compressor is to be run at slower speed than normal, or evaporation is to be at lower temperature than 15 deg., pipe length can be less but not in direct proportion to the value of H to be removed, since the value of K will be affected by cooling water velocity, which will be lowered to absorb the less amount of heat, maintaining the same temperature difference. Length needed is in proportion to area required, hence, for constant temperature difference,

$$\frac{L_1}{L_2} = \frac{A_1}{A_2} = \frac{H_1 K_2}{H_2 K_1} = \frac{H_1 \sqrt{V_2}}{H_2 \sqrt{V_1}}$$

For a given diameter of pipe,

$$\frac{V_1}{V_2} = \frac{H_1}{H_2},$$

$$\text{so that } \frac{L_1}{L_2} = \frac{H_1 \sqrt{H_2}}{H_2 \sqrt{H_1}} = \frac{\sqrt{H_1}}{\sqrt{H_2}}$$

and pipe length will vary as the square root of heat to be removed from the refrigerant. The above is from equation (1). For larger pipes, using equation (2), the result is,

$$\frac{L_1}{L_2} = \left(\frac{H_1}{H_2}\right)^{2/3}$$

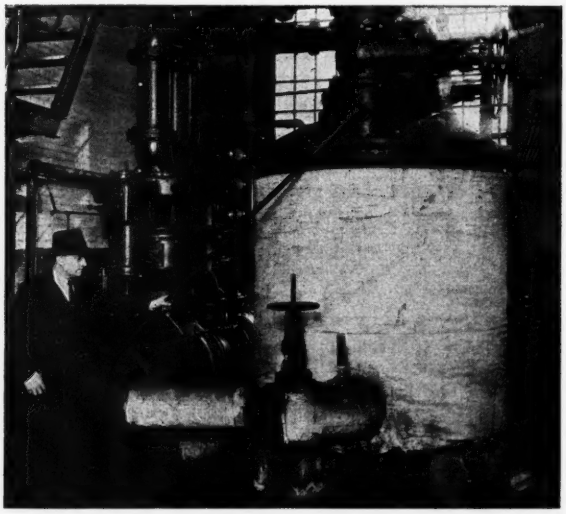
From these relations, the curves of Fig. 2 are derived, showing the reduced length needed if a plant is to be run at low capacity, so that H is reduced.

Maximum velocity of 300 ft. a min. will usually give a friction loss of 25 ft. head of water or less. In case the cooling water is at low head, the actual friction loss should be checked. Usual combinations of inner and outer pipe, such as ¾-in. in 1¼ in.; 1-in. in 2-in.; 1¼-in. or 1½-in. in 2½-in.; or 2-in. in 3-in. will ordinarily be found to give ample area of annular passage for the refrigerant.

Water Cooler

FOR SOME 15 yr. a 35-t. steam jet refrigeration unit installed by the Union Switch & Signal Co. has served cool drinking water throughout their large plant at Swissvale, Pa. The plant normally employs about 3,000 persons, and the cooling system circulates cooled drinking water through more than one mile of cork-insulated pipe, ranging between 2½ and 1½ in., to about 80 drinking fountains scattered throughout the works and offices. The cooled water leaves the refrigerating unit at a temperature of approximately 43 deg. F., and returns to it at 46 deg. F. the unit being operated at about half its cooling capacity.

The unit consists of a water-cooling evaporation tank served by two steam ejectors in parallel, each of one-half



SINCE 1918 THIS 35 T. WESTINGHOUSE STEAM JET REFRIGERATION UNIT HAS COOLED DRINKING WATER FOR THE UNION SWITCH & SIGNAL CO. PLANT

the total capacity. These ejectors exhaust into a Leblanc type jet condenser driven by a 30-hp. squirrel cage motor. A storage tank for the cooled drinking water is located in the basement, directly underneath the refrigerating unit on the main flow of the plant's power house. A float controlled make-up valve maintains the proper level in the evaporation tank. The complete unit, when operating at half load, requires 1010 lb. per hr. of steam at 90 lb. ga. pressure, and the condenser 300 g.p.m. of cooling water. Circulation of the cooled water through the long piping system is maintained by means of a steam-driven duplex reciprocating pump.

From the time Dr. William Cullen, in 1755, subjected water to a vacuum, which he produced with an air pump, and increased evaporation to the extent of making ice, experiments in a method of producing and maintaining the required high vacuum economically and in a commercial way continued unsolved until 1906. In that year Maurice Leblanc succeeded in solving the problem of perfecting an apparatus for the production of refrigeration by the sole use of water. By his system vapor is displaced and compressed to atmospheric pressure by a steam jet. Heat is required for the evaporation of water, the vapor carrying the heat away and transferring it to the cooling water while undergoing condensation.

Review of Water Hammer Theory

ABSTRACT OF THE SYMPOSIUM ON WATER HAMMER PRESENTED AT THE JOINT MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AND THE AMERICAN SOCIETY OF CIVIL ENGINEERS IN CHICAGO DURING ENGINEERING WEEK

ONE OF THE OUTSTANDING features of the engineering meetings held in Chicago during Engineering Week early this summer was the symposium on Water Hammer presented under the joint auspices of the A.S.M.E. Hydraulic and A.S.C.E. Power Divisions. It had been recognized for some time by engineers concerned with the study of water hammer that many valuable contributions had been made on this subject but that many phases of this most important problem had not been adequately covered in the English language. Recognizing this difficulty, a committee was appointed by the American Society of Mechanical Engineers to review the existing theory on water hammer with a view to summarizing this theory and comparing the various methods employed. From this study it was found that the subject of water hammer had been covered fully in regard to conduits of uniform thickness and diameter but that data were lacking on the more involved problems of conduits having variable thickness and diameter and those having branch pipes. Arrangements were made with various engineers to present treatises on these phases of water hammer in a symposium.

The committee (composed of Norman R. Gibson, Eugene E. Halmos, Lewis F. Moody, Roy S. Quick, Earl B. Strowger and S. Logan Kerr, chairman) prepared an introductory report outlining the history of water hammer theory, classifying the subject under five essential divisions.

Case I—Conduits of Uniform Thickness and Diameter (simple conduits). This case covers many actual installations and the committee found that the basic formulas of Allievi, N. R. Gibson, R. S. Quick and the arithmetic integration method published by N. R. Gibson are all in exact agreement for simple conduits.

Case II—Conduits of Variable Thickness and Diameter (Complex Conduits). The effect of reflection and transmission of pressure waves at points where a change in thickness or diameter occur will affect materially the magnitude and shape of the pressure-time relation, and will in many cases result in excess pressures much greater than result from the use of the theory for simple conduits.

Case III—Conduits Having Branch Pipes (Compound Conduits). The reflection of waves from branch pipes and dead ends affect materially the maximum pressure surge, and the reflected waves must be considered if an accurate determination of water hammer is to be made, in the various portions of the conduit.

Case IV—Water Hammer in Pump-Discharge Conduits. This very important water-hammer problem is dealt with in the committee report, but complete theory on this phase of water hammer is not yet available.

Case V—Surge Tanks. The surge tank is studied in its relation to water hammer as distinguished from its function of regulating flow in the conduit. The effect of varying sizes of surge tanks on the water-hammer conditions has been studied.

HISTORY OF WATER HAMMER THEORY

In studying the various treatises of water hammer, the first significant contribution appears to be that of Michand published in 1878 where the author noted the oscillating character of water hammer and considered the influence of the elasticity of the walls of the conduit and the elasticity of the water as a form of air reservoir of variable capacity. Many other treatises were published, the most important of which form a historical standpoint in the experimental work of Joukowsky in St. Petersburg in which he developed the law for instantaneous water hammer in a water conduit. This is known as the Joukowsky wave formula and he first established the rate of propogation of this wave and proved that the maximum water hammer was equal to aV/g.

Allievi's work, published as his notes in 1903 and extended in 1913, gave the mathematical analysis of water hammer and presented simple charts for the determination of the maximum pressure rise for uniform closures in simple conduits. This treatise was translated in many languages and forms the basis for virtually all of our present theory of water hammer. In at least one case, that of N. R. Gibson, a detailed theory was developed independently of Allievi which gives identical results. These treatises dealt primarily with simple conduits having uniform thickness and diameter and consequently uniform velocity of the water and uniform velocity of the pressure wave. Based on Allievi's theory, studies were made which considered other forms of conduits—those having variations in diameter and thickness and also branch pipes and other complications. These were published in various languages. A recent treatise by Prof. L. Bergeron (French) in 1932 on the graphical solution of water hammer problems is of great interest and should be of value to American engineers.

With regard to American water hammer literature, it was found that the early researches of R. D. Johnson outlined the formulas for the form of the pressure time wave and its maximum, and also the limits of accurate application. Fanning, Talbot, Vensano and Minton Warren attempted to present simple formulas for the determination of the maximum water hammer pressure but these have limited application. It remained, however, for N. R. Gibson to develop the basic theory of water hammer as a series of instantaneous water hammer waves, the arithmetic summation of which produced a curve of pressure with respect to time. Mr. Gibson's work included two methods, one using rigid formulas and the other employing simple arithmetic integration which permits the solution of problems in-

volving several unknowns. The most extensive experimental work on water hammer conducted in the United States was undertaken by the Southern California Edison Co. under the direction of H. L. Doolittle and R. M. Peabody. This work consisted of the construction of an experimental pipe line of considerable length and tests involving simple conduits of uniform diameter and thickness and also more complicated forms involving variations in thickness and diameter of branch pipes.

Simplified Derivation of Water Hammer Formula

Recent contributions to water-hammer theory include the important paper presented by Mr. R. S. Quick in 1927 at the Spring meeting of the A.S.M.E. This paper analyzed in detail the approximate formulas which had been published from time to time and compared the accuracy and limitations of these formulas for various applications. Mr. Quick also presented a simple and accurate chart for the rapid computation of maximum pressure rise with uniform gate motion and complete stoppage of the water column. This chart checks independently the results obtained from the charts of Allievi mentioned above, and also the detailed computations based upon the various water-column theories. Mr. Quick has also developed a convenient method of solving water-hammer problems by formulas which represent a simplification of Mr. Gibson's method and which facilitate the detailed computation of the pressure-time curve and the consequent determination of the maximum pressure rise. Another contribution was made several years ago in the paper by S. Logan Kerr, which described in detail the effect of non-uniform gate motion and the variations of discharge with respect to gate motion. The critical condition which arises from the closure of the control mechanism from intermediate points was outlined fully, and the ideal form of gate movement with respect to time was given.

In addition to the classification of existing material on water hammer by the committee, the symposium included the presentation of seven papers dealing with different aspects of the problem. The first of these, entitled "Simplified Derivation of Water Hammer Formula" was presented by L. F. Moody, professor of hydraulic engineering, Princeton University. This paper developed the essential water hammer formula, such as the velocity of the pressure wave and the value of instantaneous water hammer by the use of Newton's second law of motion, to present to American engineers the classic formula for water-hammer problems, in a different manner than employed in many other treatises. The successive phases of instantaneous water-hammer phenomena are shown in illustrations to give a better conception of the essential elements of this problem.

High-Head Penstock Design

The most important paper, however, was one on High Head Penstock Design by A. W. K. Billings, vice president, The Brazilian Traction, Light and Power Co., Ltd., Rio de Janeiro, Brazil; and O. H. Dodkin, Hydraulic Engineer, and F. Knapp and Adolpho Santos, Jr., Asst. Hydraulic Engineers, Sao Paulo Tramway Light and Power Co., Sao Paulo. This joint paper repsents the results of approximately eight years research and experimental work on high head penstocks, which as centered around the Serra de Cubatao Development of the Sao Paulo Tramway Light and Power Co. in Brazil. A complete new method for high-head penstock design has been outlined, based on this research work, which emphasized the importance of considering accidental factors as the limiting feature of design rather than the conditions for normal governing, which would produce only moderate water hammer. The criteria for design of penstock from the point of view of hydraulic conditions have been outlined in detail and the mechanical criteria of design are discussed extensively, taking up the importance of material characteristics, the variations which occur during manufacture, the types of pipe available, and methods of manufacture and construction in so far as they have a direct effect upon the safety of the completed conduit. The theory of surges for penstocks of variable thickness and diameter is treated at length, and the complete formula is included, together with numerical examples which permit engineers to apply this theory to any similar problem. Of prime interest are the field tests which produced instantaneous water hammer on the full-size penstock and the comparison of the results of this field work with the theory presented in this paper which considers the effect of partial reflection of water-hammer waves at points where variations occur in thickness or diameter.

Walter Dreyer of the P. G. & E. Co., San Francisco, in a paper on the influence of water hammer on design of high head penstocks at the Drum Plant and Tiger Creek Plant, outlined in general the practice of one of the larger power companies on the West Coast in regard to water hammer conditions in high-head penstocks in so far as the design and safety of the conduit are concerned. Two important developments are described and comparison is made between the results of actual field tests for water hammer and the theoretical values upon which the penstock design was based. The essential design factors are included together with the general allowances for stress in such conduits.

Water Hammer in Compound Pipes

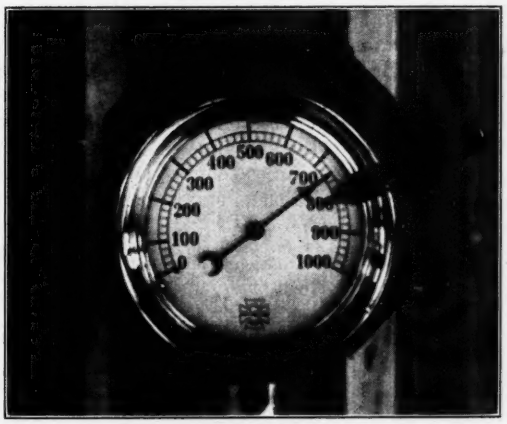
The fourth paper discussed the "Computation of Water Hammer Pressures in Compound Pipes." This was presented by Robert E. Glover of the U. S. Bureau of Reclamation, and was of timely interest since the methods outlined were employed in the design of the conduits for Boulder Dam Power Plant, which included in addition to variations in thickness and diameter, branch pipes and dead ends in the conduit resulting in a highly involved problem in water hammer determination. This paper outlines the theory used for the computation of water hammer in such conduits and gives the methods of calculations, together with a typical example, and shows the means of determining the water-hammer pressures at different points in this compound conduit due to the cutting off of flow on the extremely large turbines. Comparative curves from other experimental investigations are included. This paper presents a rather novel method of attack of water-hammer investigations in such difficult situations.

The remaining three papers discussed the effect of surge tanks and surge tank risers on water hammer computations, surge control in centrifugal pump discharge lines and the water hammer tests in the Croton Lake Pumping Plant and were presented by Eugene Halmos, Roy S. Quick and S. Logan Kerr, respectively.

Readers' Conference

Gage Hand Indicator

INABILITY of an engineer to determine accurately the discharge line gage reading from his post on the engine powering the pump led him to devise a simple and effective gage indicator. A 4-in. arrow, cut from a tobacco tin and painted red, was fastened to the back of an ordinary spring clothespin. Then if, as



QUICKLY ATTACHED AND INSTANTLY ADJUSTED, THIS ARROW AIDS IN MAINTAINING EXACT PRESSURES

was the case in the illustration, working pressure was to be 800 lb., the clothespin was clipped to the gage rim with the tip of the arrow over the desired reading. It was then a simple matter for the operator to stand on his engine and regulate the speed so that the arrow and the gage pointer formed a straight line. The incidence of gage hand and arrow was readily apparent, even though the exact value of the gage reading was in doubt.

Longview, Tex. ELTON STERRETT.

Protection for Small Motors

THE GENERAL rule for small motors say from 5 hp. down, is to tuck them away on the floor or a shelf, in the ceiling, or down under the driven machine, where they cannot be seen, much less oiled. These motors are switched with snap switches, open knife switches, safety switches, and sometimes small across the line starters. Some have fuses, some none, a few have thermal cutout boxes.

Many have attachment plugs, and attachment plugs are approved by the Underwriters Code for certain classes of equipment. These small motors may be found in nearly every industry and on all sorts of equipment. They require very little running current as a rule. For instance ½-hp. single-phase, 220-v. motor requires approximately 3½ amp. and with a 300 per cent rating for the fuse, in order to allow for starting current, gives 10½ amp. for proper fuse, or a standard 10-amp. fuse would be used. I find that this high rating is seldom needed to start the average load, 6 or 8 amp. usually being sufficient, and the smaller rating is added insurance for the motor.

On single-phase motors, with short-circuiting devices, it is often possible to vary the current used in starting by adjusting the nut which holds the governor spring. Tightening this nut prevents the motor from short-circuiting too soon, when this happens the current is higher than normal and it requires a larger fuse for a motor to start a given load under this condition.

A half-horsepower motor on 220 v., 3-phase circuit, starting across the line, draws approximately 2.5 amp. running full load. At 300 per cent fuse rating for full voltage starting, the fuse would be 7½ amp. or a standard 8-amp. fuse would be used.

For all motors over 1 hp. the latest Underwriters Code requires a thermal cutout device. These thermal relays are arranged so that the abnormal current drawn by a motor, due to any cause, will be shut off by a heating element when the motor becomes hot.

Relays are sometimes used to operate on certain percentages of a given full load current and different sizes of heater elements are required for different size motors. On the ½-hp. single phase motor mentioned above the relay would be set at 8.75 amp. or 250 per cent of full load current, 250 per cent rating is also required on full voltage starting of the ¼-hp., 3-phase motor.

Below is given the ampere ratings and fuse required for motors up to 1-hp., single-phase, specified by the Underwriters Electrical Code. A 1-hp., single-phase motor requires at 220 v. approximately 8 amp.

Full load amp. motor	Fuse rating	Time limit device
1	2	1.25
2	3	2.50
3	4	3.75
4	6	5
5	8	6.25
6	8	7.50
7	10	8.75
8	10	10.

If the above table is adhered to it is almost impossible to burn up a motor and the fuse will be a warning that all is not well. If this warning is heeded much time and money will be saved.

Tarrant, Ala. GRADY H. EMERSON.

Commended Cooperation

INTERCONNECTED OPERATION of electric generating plants has become standard practice. The younger generation of operating engineers has grown up with it. It was not so easy for the older men in station service to readjust their work to the conception of subordinating everything to securing maximum regional economy, but most of them did so, and a word of appreciation for their open-mindedness is not amiss.

For decades power plant operation was conducted on the basis of loading every unit so far as possible along the more efficient range of its output curve. Few then saw a steam plant floating on the line to correct power factor or for stand-by service, though individual units had to be thus operated in many cases. Plants were self-sufficient and engineers knew little and cared less about what went on 50 to 100 mi. away. The day's work was concentrated within four walls and reputations rose and fell with local plant economies.

All maturer operating men know how interconnection has revolutionized the handling of individual plants. That personnel in general responded so willingly to the new requirements, realizing that their task was to do the best they could with the loads and equipment authorized for service as a part of a regional set-up, reflects no little credit upon their coöperative spirit. System operators' meetings have fostered acquaintance and aided efficiency but at bottom professional unselfishness has been the mainspring of success in this new deal in power production and delivery.

Cambridge, Mass. H. S. KNOWLTON.

Cooperative Power Supply

A NEW OUTLOOK is apparent in the power field. It more generally recognizes the treatment of every power production and delivery problem from the angle of minimum overall cost at the consuming center. Progress in generating plant design has given fresh impetus to decentralization and sharpened competition between isolated plants and utility systems. Energy interchange between industrial generating plants and utilities has reached a stage of great technical interest, and is quietly working out the solution of the cost problem in many local situations. Bias for or against a particular type of generation is diminishing, although deep-rooted beliefs in the supremacy of central station service and the cheapness of energy produced as a by-product from steam sway many negotiations.

Economic pressure has dulled the edge of enthusiasm for producing power on the premises merely as a matter of pride. The situation is doubly interesting because the old sense of aloofness between the two schools of power thought is vanishing under an urge to coöperate where feasible; to save idle investment and to work out the best engineering methods for supplying power in individual cases. Selfish interests are still strong but men are more willing to discuss possibilities of reaching the economic solution. The power plant engineer, superintendent of power in industry and the consultant of the power user never faced a better opportunity to serve their superiors and clients in intricate but fascinating situations.

Cambridge, Mass. H. S. KNOWLTON.

Magnetically Operated Refrigerator Valves

MAGNETICALLY operated valves are now much used for controlling the various pipe lines. Dirt and scale getting on the seat may prevent the valve from closing tightly. This not only causes the valve to leak but sometimes damages the valve faces. Before fitting these valves, the pipework system should be blown out and, just ahead of the valve, a filter should be placed to remove any scale.

The usual type of magnetic valve will operate satisfactorily provided the voltage does not vary by more than 10 per cent above or below normal. Continuous over-voltage will, in time, cause the coils to burn out, while under-voltage may so reduce the magnetic pull that the plunger is not lifted, causing the coil to heat up and finally burn out if continued.

Proper fusing of the coils will to a great extent eliminate the danger of a burn out. The contacts of the switches must be kept clean and in adjustment.

One defect of magnetic switches is that they may be noisy and emit a humming sound. This is caused by the plunger being out of alignment in the coil. In these cases the solenoid frame should be loosened, while the magnet is energized, and the magnet moved slightly and slowly until a quiet position is found and then the frame tightened in this position. If the humming cannot be eliminated in this way the position of the plunger may be shifted slightly by changing the position of the lever on the operating shaft. This should remedy the humming. Too tight packing of the spindles makes the valves work stiffly and puts more work on the operating coil. The spindles should be packed only tight enough to prevent leakage, and repacked as soon as the packing becomes hard.

Herts, England. W. E. WARNER.

Unusual Motor Operation

FREQUENTLY THE maintenance man is confronted with vexing problems in electrical operation. The author was called upon to solve such a problem some time ago.

The report came in that a motor seemed to "growl" under load. The unfamiliar sound was detected by the machine operator who was accustomed to the steady hum of the various machines, and his report saved the motor.

Upon investigation the circuit was found to consist of three 25-kv-a. transformers connected in closed delta feeding the power service. The motor in question, being one of many tapped to the service, was started by a two-way starting switch. This switch had fuses directly in the line for running and starting fuses connected through the compensator coils.

It was observed that the motor started satisfactorily and no noise developed in the running position except during the heavy loads. Bearings and spacing between armature and rotor were checked and found in good condition. It was then decided that the fuses should be checked. It developed that the starting fuses were in good condition, which allowed the motor to start three phase, but that some time one of the running fuses had blown, thereby allowing the motor to operate single phase after it had come to speed. This fuse was replaced and heavy loads applied with no apparent noise emanating from the motor.

Fortunately heavy loads had been infrequent, or the motor may have burned out by operating single phase.

From the foregoing, a good idea to keep in mind is that when a three phase motor starts making a growling noise under load, a check of the running fuses should be made immediately to determine if one fuse has blown.

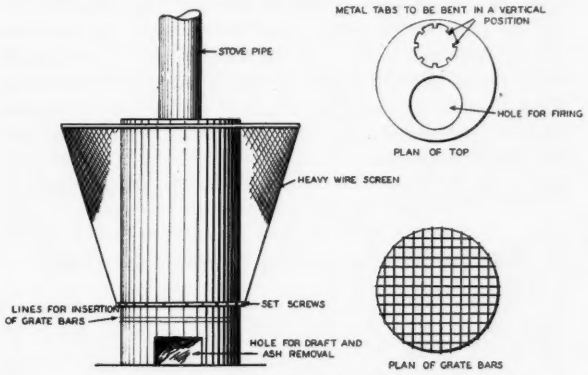
Long Island City, N. Y. M. D. SIMMONS.

Dry Sand Required for Blasting

MR. JAMIESON'S ARTICLE on sand blasting equipment, in a recent issue of Power Plant Engineering, was most complete in all respects but one which I believe to be of major importance. That one is the problem of drying the sand.

Several years ago while working for an eastern railroad, I was given the job of doing all the sandblasting jobs that might be necessary on our division. My first job, that of removing the accumulated coats of paint from a steel car, was under way when I discovered that, as Mr. Jamieson says, dry sand was most necessary. After drying sufficient sand in various makeshift ways, I finally made a satisfactory dryer.

Any old oil drum may be made to serve this purpose. Run heavy steel rods through the drum at a distance of about 1½ ft. from the bottom to serve as a grate.


METAL TABS TO BE BENT IN A VERTICAL POSITION
STOVE PIPE
HOLE FOR FIRING
PLAN OF TOP
HEAVY WIRE SCREEN
SET SCREWS
LINES FOR INSERTION OF GRATE BARS
HOLE FOR DRAFT AND ASH REMOVAL
PLAN OF GRATE BARS

SAND DRIER MADE FROM OIL DRUM

Cut a hole large enough to admit air for draft and a shovel for removing the ashes at the bottom of the drum. Cut two circular holes at the top, one for feeding the stove and one for the stovepipe, leaving several tabs of metal in the pipe opening so that they may be bent in a vertical position to hold the pipe in place. This stove may then be set up in any convenient place. A funnel shaped wire screen is clamped on the stove to hold the sand against the heating surface. As the sand dries it sifts through the ½ in. annular space between the drum and the lower part of the screen and is then ready for use.

The necessity of using dry sand cannot be too greatly stressed as small amounts of wet sand will easily clog the hose and cause considerable delay.

Chicago, Ill. T. HANSON.

Crank Case Oil

TO THOSE engineers who have studied lubrication, it is a great economic waste to burn oil drained from crank cases of internal combustion engines, as the article on above subject suggests in the July issue.

Several methods of satisfactorily reclaiming or purifying oil from Diesel engine crank cases are available. Some use centrifugal equipment, and some re-refining equipment for the oil drained from gasoline motors. If, after re-refining such oil, the engineer cannot overcome his prejudice against a darkened or changed color of the oil, he can still use this re-refined oil for many bearing jobs.

It should be known by all engineers that the U. S. A. Government Aviation Dept. has reclaimed and used constantly, as new oil, their drainage from all motors for many years, and that this practice is being followed by the largest fleet owners.

For the recent study of such practice, I offer the following references:

"Oxidation Makes Oil Better," by R. O. King. Automotive Industries, April 22nd, 1933.

"Oil Reclamation Economy," by G. T. Hook. American Soc. of Automotive Engineers Journal, Jan., 1933.

"The Chemical Mechanism of Lubrication," by Wm. T. Parrish. Paper read before Amer. Soc. of Mech. Engrs. at Nat. meet., Dec., 1932.

"Specififfications of Lubricating Oils," Oil & Gas Trade Journal, Jan. 1st, 1931. B. W. D.

Oils for Anti-Friction Bearings

IN MR. SCHAPHORST'S article on Anti-Friction Bearings in the August issue, page 359, are stated several opinions in regard to the use of animal or vegetable oils on such bearings with which I take issue.

It is true that such oils sludge readily in presence of moisture or steam, but mineral oils are also subject to the same condition; moreover, they lose their lubricating efficiency in the presence of water, more than vegetable oils.

When a certain manufacturing company brought out its clarifier, it was a small unit, driven by a spiral gear at 10,000 r.p.m., and we had great difficulty keeping any oil in the crank-case, due to foaming caused by the intense heat. We tried everything recommended by experienced oil refiners, straight mineral oils and compounded oils, and found little difference between them. I had in the laboratory, a gallon of soya bean oil with an acid number of 6. This gave good results, but not much better than the mineral oils, and being a semi-drying oil, I knew that it was only a question of time when it would be too thick to flow through the ports leading to the ball bearings. In the meantime, the gears themselves told us the trouble, and by giving a little more relief to the spiral, they soon broke in, and ran as cool as could be desired. We then found that any oil that would give good service in an automobile engine, would answer well.

At no time did we find any evidence of sludging, for while both water and live steam were used in clarifying, the crank-case was enclosed so that nothing could get to it. During the four years that I was installing oil separators and experimenting on different oils, mineral, vegetable and animal, I was frequently asked, "What is the best lubricating oil?" My answer was, "I don't know. I have been using oil for nearly forty years and have changed my mind so often, that I don't know where I stand."

In my youth, when we thought 80 lb. was high pressure, many used tallow oil. As a lubricant, it has no superior, but with an increase of temperature over 300 deg., the stearic acid attacks iron, so we went to a straight mineral oil; with wet steam it did not lubricate well, so, on hoisting engines, we could not reverse under pressure, and Corliss valves would groan dismally, so

we used ten per cent of tallow oil and thought we had settled the question for good. Then came superheated steam, and we found that mineral oils were perfectly satisfactory and cheaper, the stearic acid having again shown its disagreeable side. It is an established fact that a tiny percentage of fatty acid does improve lubrication.

A compound oil is easily detected by filling a bottle half full, and adding a little concentrated sulphuric acid, 66 deg., and shaking thoroughly. The saponifying element will be charred and turn black, with a straight mineral oil the acid will settle to the bottom and be found to be dark red or even brown, as pure paraffine oil is not acted on by acid, hence its name, *para affinis,* without affinity.

One vegetable oil is in a class by itself, castor oil. It is the only common oil that is miscible with alcohol in all proportions, is very resistant, and at one time was very popular for aeroplane engines running at high altitudes. It is also used by some in Diesel engines, not alone, but as booster to the usual oil. I have never heard it charged with corroding iron.

Much has been said and written about "100 per cent Pennsylvania." There is a remarkable uniformity about the crude from the Pennsylvania field, and it is practically all paraffine base. Some equally good crudes are produced in Wyoming, and some parts of Oklahoma and Texas, after the sulphur has been removed. If reports are true, the highest grade crude yet found in America is the Kettleman field in California and Calgary, Canada, but I have not yet had an opportunity to test either.

It is impossible for a vegetable or animal oil to break down and become alkaline; use and age will increase the fatty acid content and lower the iodine value of either one. Such oils are glycerides of a fatty acid; the glycerine is the same, but the fatty acid varies with the kind of oil. Any alkalinity found in a used oil has come from some outside source.

St. Louis, Mo. L. R. Baker.

Center of Gravity and Top-Pull Belt Drives

I am in receipt of a letter from an engineer who is operating a top-pull pivoted motor drive. He read my short article in the July number of Power Plant Engineering and said: "This is the first article I have ever seen on the subject of top-pull belts as applied to pivoted motors. Your analysis is correct as I see it. My only criticism is that you indicate the center of gravity of the ensemble as being in the center of the shaft which is not correct. The center of gravity is invariably below the center of the shaft. However, the method of calculation is not affected in any way. That is, your analysis is correct."

The engineer is right in the statement above. He makes a point that should have been brought out in my article. It is obvious that with top-pull belts the lower the center of gravity the better—the more stable the drive and the less possibility of the motor getting into the position which I labeled as "dangerous" in Fig. 3.

Newark, N. J. W. F. Schaphorst.

Job Hunting

In the course of human events it sometimes becomes necessary for an engineer to seek a new position after having been employed continuously for several years. An engineer's ability to sell himself to a prospective employer gets rusty just as any unused machine. This together with a slight nervousness puts him at a decided disadvantage. Especially so, if the employer happens to be one of those men who is not easy to talk to. Another thing that places an engineer at a disadvantage is the small number of employers he is acquainted with.

He has been employed a long time at one plant, working from 8 to 12 hr. per day, and 6 or 7 days a week and has had no opportunity to get acquainted with other employers. He therefore has to seek employment from perfect strangers.

Usually an applicant for a position is given only a short period of time in which to state his qualifications for the position he seeks. It is the writer's opinion that an engineer seeking a position should state his qualifications in as short a time as possible and in an honest straight-spoken manner. And to prevent nervousness, internally assume an indifference as to whether he gets the position or not.

Indianapolis, Ind. Fred E. Bond.

Embrittlement in Steam Boilers

During the last year I have received information from several sources that persistent rumors are being circulated to the effect that I have changed my opinion in regard to the cause of embrittlement in steam boilers and the use of sulphate to prevent this difficulty. One of these rumors is to the effect that a large power plant operating at a steam pressure in the neighborhood of 400 lb. maintained the 3:1 sodium sulphate-to-total alkalinity ratio as recommended by the Boiler Code Committee of the American Society of Mechanical Engineers, and that embrittlement cracking took place. Another is to the effect that I have admitted that caustic is not one of the contributing causes of embrittlement.

It is extremely difficult to trace rumors to their source, and once a rumor is started, it spreads very rapidly. I have answered numerous inquiries in which men hearing these rumors have written to me directly. However, it becomes very difficult to stop these rumors by writing a few letters. I would like to make a public statement at this time to the effect that these rumors are not correct. I still believe that embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses are inherent in the construction and operation of the boiler, while the chemical attack is caused by the presence of sodium hydroxide in the boiler water. I also believe that the presence of sodium sulphate in the boiler water tends to retard the embrittling effect of the sodium hydroxide, and if in proper proportions, will stop it entirely. I hold this opinion due to the fact that no evidence has been presented to the contrary. If at any time such evidence is produced, I will be willing to investigate the evidence and make a public statement as to the results. I would appreciate it very much if you could publish this statement for me in your publication.

Urbana, Ill. Frederick G. Straub.

N.A.P.E. Holds Fifty-First Annual Convention at Buffalo

LAKE ERIE PORT HOST FOR DELEGATES AND VISITORS AT CONVENTION AND POWER SHOW, AUG. 28 TO SEPT. 2

DURING THE WEEK of Aug. 28 to Sept. 2 delegates of the National Association of Power Engineers met in Buffalo, N. Y., for the Fifty-First Annual Convention. The convention held in conjunction with the Niagara Frontier Power Conference, Power Show and Mechanical Exposition was attended by 189 accredited delegates representing a total mileage of 139,200 miles.

On Monday morning the official opening of the Conference, in the Hotel Statler, was called to order by Karr Parker. The first speaker on the program was Norman Gibson of the Niagara Hudson Power Corp. who outlined the power development of recent years, and particularly the section covered by the Niagara Frontier. D. J. Mahoney of the American Society of Heating & Ventilating Engineers then discussed briefly many interesting engineering developments which were taking place today and particularly stressed the need of greater and more close coöperation between all engineering organizations at the present time. The next speaker, L. A. Harding, also stressed the importance of coöperation among the various engineering societies while National President Thompson of the N.A.P.E. touched briefly on the part the N.A.P.E. has taken in the development and application of power in all industries, discussed the many natural resources of Buffalo and vicinity, particularly as applies to power development, and closed by expressing his cordial appreciation of the coöperation with the N.A.P.E. during the present year. W. A. Bradbury of the Buffalo, Niagara and Eastern Power Corp. gave an interesting address on the history of the power development of Niagara Falls which has a potential capacity of 6,000,000 hp.

POWER SHOW

In the evening the Niagara Frontier Power show was officially opened in the Broadway Auditorium by George M. Diebold who introduced Karr Parker as the presiding officer of the evening. Mr. Parker in a brief address welcomed the delegates, visitors and exhibitors to the show. President Thompson of the N.A.P.E. felicited the Local Committee and all other coöperating bodies on their splendid performance under the most difficult circumstances during the past year, and President John H. Allen of the National Exhibitors Association stated that he was particularly impressed with the determination, enthusiasm and aggressive effort by which the program had been carried out during the past year.

The opening session of the Fifty-first Annual Convention of the N.A.P.E. was called to order Tuesday morning by Chairman Diebold of the Local Convention Committee and the invocation was offered by the Rev. J. Boland. State Deputy P. F. Cassidy pointed out the many remarkable features of the State of New York, its many natural advantages, its place in the history of the Nation. Response to Mr. Cassidy was made by President Thompson. Welcome to the City of Buffalo was tendered by Commissioner of Public Works, W. A. Rathmann. In responding Vice-President J. A. Prudell expressed his appreciation of the cordial welcome extended. President Depew of the Buffalo Chamber of Commerce extended a very cordial and cheerful greeting to the convention on behalf of the business men of the city. Following this, Past President Pierson of the N.A.P.E. stressed the tremendous difficulties faced by the Association and the local members in carrying on during the past year. He saw an interesting promise of new life in the organization by the presence of numerous new faces which had not been seen at other conventions.

President Thompson was then presented with a gavel made from the largest tree blown over by the greatest hurricane ever experienced in that section. The meeting was then turned over to President Thompson who proceeded to name the convention committees.

PAPERS PRESENTED

Tuesday afternoon session was occupied with business and committee reports and two lectures, one on Air Conditioning by A. E. Stacey of the Carrier Engineering Corp. and another on Refrigeration Progress by David Fiske of the American Society of Refrigerating Engineers. In the evening a banquet was held in the Statler ball room. This was followed by a demonstration on the subject of Sound, Electricity and Light by Dr. J. O. Perrine of the Bell Telephone Laboratories of New York City.

Wednesday was taken up by business and two papers, one on Recent Developments in Steam Generating Equipment by Henry B. Jones of the Babcock & Wilcox Co., the second on Modern Steam Power Plant Equipment by C. R. Soderberg of the Westinghouse Electric & Mfg. Co. In the afternoon the delegates made an inspection trip to the Huntley Station.

Thursday morning session included a paper on Diesel Engines by A. Boehm of the Worthington Pump & Machinery Corp. and one on The Maintenance of Wire Ropes by F. S. Burtch of John A. Roebling's Sons Co. At the conclusion of the lectures the convention received the annual visit of the Ladies' Auxiliary and the Annual Memorial services closed the session. The Thursday afternoon session was devoted to business.

On Friday National officers for the following year were elected. These included J. A. Prudell, Wis. 1, president; Geo. M. Diebold, N. Y. 16, vice-president; Ed. J. Burke, Pa. 9, treasurer; Fred W. Raven, Ill. 1, secretary; C. A. Belmore, Mass. 30, conductor; E. Baile, Iowa 2, doorkeeper, and Thomas Gambuete, Mich. 7, trustee. Minneapolis, Minn., was selected as the 1934 convention city.

New Equipment

New Foxboro 2-in. Indicating Gage

IN ANSWER to demands a small size, moderately priced indicating gage with a full length 270 deg. scale, the Foxboro Co., Foxboro, Mass., has developed its Model DH. This gage uses a full length Bourdon spring, is accurate to within 1 per cent of its total scale and carries the same guarantee as the larger Foxboro instruments. The connection may be either top, bottom, left or right side. Dials may be had either with black background and white block figures, or white background and black figures. Any range from 0-15 lb. per sq. in. to 0-300 lb. per sq. in., as well as 0-30 in. mercury vacuum, can be furnished.

CO_2 Regeneration Plant

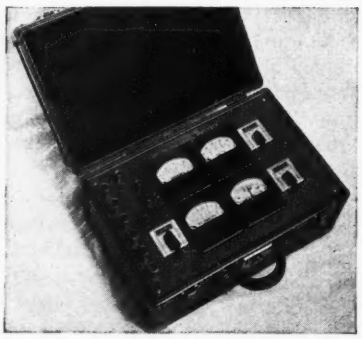
AUTOMATIC CO_2 regenerating system for fermenters is announced by the Carbondale Machine Co., Carbondale, Pa. This new regeneration plant reclaims the CO_2 gas directly from either open or closed fermenters. It delivers the CO_2 in liquid form and automatically adjusts itself to the quantity of gas produced at the fermenters.

The important advantage of a liquifying system lies in the fact that a large quantity of CO_2 can be stored in a relatively small space. For brewers another advantage is that the liquid CO_2 may be used for carbonating beer in the same way that the compressed gas is utilized, or it may be sold to those consumers who employ this liquid for other purposes in other industries.

Automatic operation is another feature. The plant operates substantially as an automatic unit, which includes ridding itself of the excess air and water that may be carried over with the gas. It does not require frequent inspection or manual adjustments.

New Industrial Tester

A NEW portable A. C. Testing set, known as the Industrial Analyzer, suitable for testing household electrical appliances and industrial apparatus and motors up to 100 hp. 440 v. is announced by the Westinghouse Electric & Manufacturing Co. Capable of making complete



tests up to 125 amp. 500 v. A. C., the analyzer is, in reality, a miniature portable three-phase switchboard panel in a carrying case complete with all necessary switching equipment, transformers, and resistors. The unit contains a triple scale ammeter 0-5, 0-25, and 0-125 amperes, a triple range voltmeter 0-150, 0-300, and 0-600 v., a polyphase wattmeter with three scales for the above voltage and current ranges, and a polyphase power factor meter with 10-100-80 scale to operate on the above voltages and currents. The instruments are of a newly designed miniature type with standard size mechanism having high overload capacity and low energy consumption. The scales of the instruments are 3½ inches long.

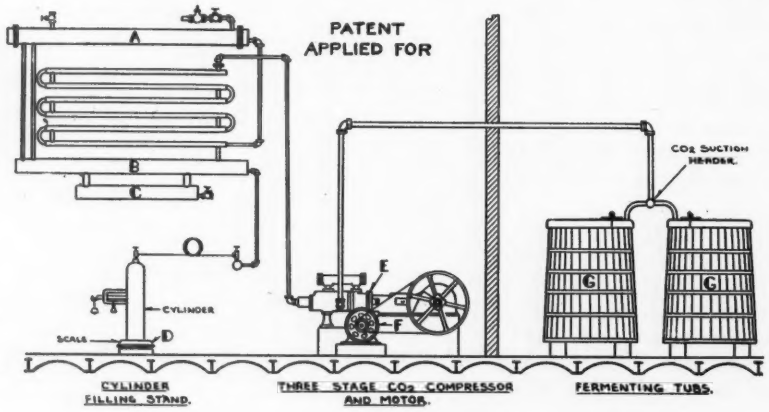
Two special lightweight current transformers with hipernik cores and with primary winding tapped for 5, 25, and 125 amp. are connected into the circuit in the conventional three phase wiring scheme to provide the multiple current ranges. The various voltage ranges are obtained by switching tapped resistors in the potential circuits.

The instrument, completely self-contained for the voltage and current ranges mentioned is mounted in a durable rugged carrying case about the size of an ordinary suit case, the dimensions being 7x11x19 in. The case is provided with a strong leather carrying handle, trunk type hasps, lock, and rubber cushioning feet. The appearance and arrangement of the instrument have been given considerable study, giving the completed instrument a finished, pleasing appearance.

Synchronous Motors

INDUSTRIAL PLANT managers and others interested in avoiding the power penalties, excessive voltage drop, heating, etc., which result from poor power factor on their distributing systems, are offered a new line of small and medium capacity synchronous motors manufactured by Columbia Electric Mfg. Co., 1292 East 53rd St., Cleveland, Ohio.

These motors may be installed as easily as ordinary induction motors, and since their starting and pull-out torques are practically the same as those of squirrel cage motors, they may be applied to almost any drive. They are self-synchronizing, and are separately excited. They give a leading power factor of 0.9 at full load, and have therefore excellent power factor correction characteristics. The poles are fitted with amortisseur windings to assure high starting torque. Full details of all sizes from ½ hp. at 1800 up to 40 hp. at 900 r.p.m. are given in the company's bulletin S-1.



New G-M Photoelectric Relay

A NEW photoelectric relay using the Visitron F2 photoelectric cell is announced by G-M Laboratories, Inc., 1735 Belmont Ave., Chicago. The complete unit designated as the FSE photoelectric relay and an auxiliary electromagnetic relay housed in a small, compact cast aluminum case 6¼ by $5\frac{5}{16}$ by 4 in. The cell can be mounted behind a glass window in the front of the

case or externally at any point within hundreds of feet of the sensitive relay. The FSE unit can be completely weatherproofed.

Because the Visitron F2 photoelectric cell requires no external voltage and no amplification, the FSE unit can be used in locations not served by electric power lines, and since there are no tubes to necessitate replacements it will operate for long periods without attention. It is consequently of great importance in controlling lighthouse beacons, night lights on boats at anchor, obstruction lights, airway beacons, highway traffic warning lights, electric signs (both battery and power operated), suburban station lights, railway signal lights and street lighting systems.

Bucket Trap

INVERTED BUCKET TRAPS, the 80 Series, announced by the Strong, Carlisle & Hammond Co., Cleveland, O., incorporate two oustanding features: the method of retaining the seat in place and the anti-balancing device.

Instead of screwing the seat directly into the trap cover, or a seat holder, the seat in this new trap is forced against a gasketed surface by a bracket which is held against

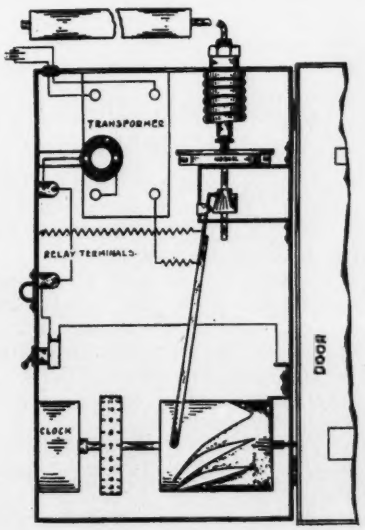
the cover by two stud bolts. By simply removing the two nuts from the studs, the bracket and seat may be lifted out. The feature is claimed to eliminate the necessity of special tools and the possibility of damaging either the seat itself or the entire cover during replacement.

The anti-balancing device consists of a valve arrangement on the bucket which automatically varies the air vent opening during the cycle of operation. This device is claimed to eliminate almost entirely the tendency to balance or dribble. This device is covered by patent protection and used by no other manufacturer of inverted bucket traps.

Strong 80 Series Traps are built of semi-steel construction, for low and medium pressures and of forged steel construction for higher pressures and super-heat service.

Building Heat Control

TRITROL REGULATORS, distributed by the Berwyn Regulator Co., 1933 So. Clinton Ave., Berwyn, Ill., is a



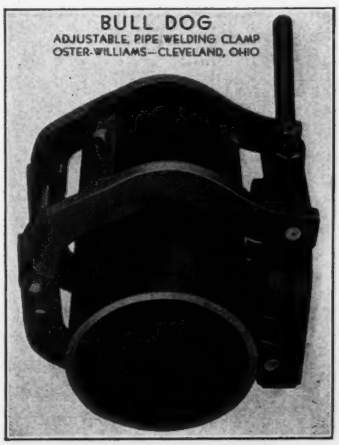
unit control device, applicable to the control of a zone, a building or a group of buildings. A variation of outside temperature causes a contact lever to move across the face of a rotating contact drum through the media of an outside bulb, flexible bellows and compound cam arrangement. The drum has contact areas and insulated areas on its surface used to make and break an electrical circuit. The contact areas increase in magnitude from one end of the drum to the other.

Thus periodic operation of the heat generating equipment is obtained, the length of the periods of operation increasing with a drop in outside temperature.

Variations of sun or wind are compensated for by the manual adjustment of the compensator which rotates the compound cam causing an increased or decreased heating affect. The drums are so designed that the heating up and the shut down periods are automatically regulated, commensurate with the outside temperature.

Pipe Welding Clamp

OSTER-WILLIAMS, Cleveland, O., have just entered the pipe welding field with a new pipe welding clamp known as the Bull Dog. It



will be made at present in two ranges, one from 4 to 6 in., weighing 18 lb. and the other from 8 to 12 in., weighing 26 lb. Other sizes will be available in the future.

One lever controls the action of the clamp, making it easy to put on and take off the pipe. It automatically centers the two lengths of pipe to be welded and adjustable screw spacers keep them the correct distance apart for efficient welding.

Metallic Lead Lubricant

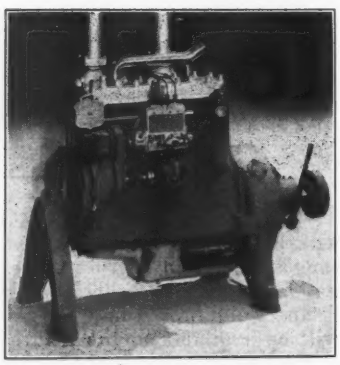
METALLIC LEAD is the protective element in a new lubricant recently developed. The lead has been broken down into such finely divided parts as to be virtually a soluble or liquid lead within a lubricant vehicle. The new product, known as Bestolife, forms a thin protective film of lead on all contacting surfaces which changes such surfaces to a continuous unbroken, anti-frictional area, according to the manufacturers, Armite Laboratories of Los Angeles, Calif.

This new lubricant has a pure metallic lead base instead of lead salts and is said to be free from chemical reactions. The minimum constituency of lead in Bestolife is 10 per cent, ranging up to 65 per cent, and is claimed to withstand temperatures up to 430 deg. and will not entirely lose its lubricating stability until the melting point of lead is reached, which is 590 deg. The principal application of the product in the power industry is for use as a pump and valve stem packing lubricant, also for plug cocks, bearings, gears, wire line and belt dressing.

Monovalve Diesel

A NEW and simple Diesel engine has recently been developed by the American Diesel Engine Co., of Oakland, Cal. This engine is of monovalve construction—using only one valve per cylinder which permits the use of conventional L-head design.

This new 4-cylinder Diesel operates at a rated speed of 1200 r.p.m. and develops 75 hp. on a fuel consumption of 0.44 lb. per hp. hr. It



is practicable to run this engine over a speed range from 200 to 2000 r.p.m. with a clear exhaust and a fuel consumption of less than 0.5 lb. per hp. hr.

A Small Light for Big Jobs

THIS PEEP-HOLE light is extremely valuable for searching out small parts of equipment to be repaired or inspected. It enables the repairman to thoroughly inspect the bearings, oil rings and small parts of motors and other equipment without disassembling.

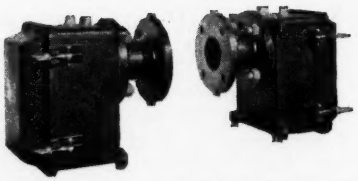
Installed at the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company, this inexpensive miniature spot light was constructed from an ordinary fountain pen type flashlight. It is attached to a flexible cord and arm in a convenient position over the

bench and is energized with a small transformer mounted on the wall. As the ordinary extension light is rather cumbersome and cannot be used for getting into the interior parts of small apparatus this trouble light has proven itself to be a time saver and a valuable addition to the inspection bench. When not in use the light may be placed in the receptacle at the end of the arm and swung aside until needed.

G. E. Smoke Density Instrument

PHOTOELECTRIC equipment for indicating and recording the degree of density of smoke passing through the stacks or breechings of power and heating plants, has been announced by the General Electric Co. Changes in smoke density are indicated on a meter. A running record of the amount of smoke passed up the stack may be obtained by the addition of a recording instrument.

The essential elements of the apparatus are:—a light source and a photoelectric relay unit. The recording instrument is optional. The pho-

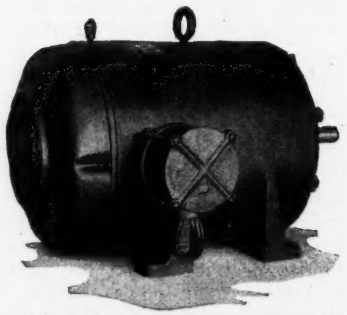


toelectric unit and the light source are designed for mounting on opposite sides of the stack so that the light beam from the light source passes through the stack and falls on the phototube. An adjustable electrical contact for operating an alarm circuit is provided which can be adjusted to any print between 20 to 60 per cent of full smoke density. Adjustment can be made by the use of a screwdriver.

Ideal Totally Enclosed Fan-Cooled Motor

IDEAL ELECTRIC & MFG. Co., Mansfield, Ohio, has developed a new totally-enclosed, fan-cooled motor. Full protection is provided against explosive dust, abrasive dust, corrosive gases or fumes, current-carrying dust, and steam or moisture. For this reason, this new Ideal motor is especially suitable for use in steel mills, metal working plants, foundries, packing plants, grain elevators, flour and feed mills, chemical plants and laundries.

The construction employs two shells—the inner shell being dust tight and enclosing windings and rotor. Tight sealing is obtained by machined metal to metal stationary

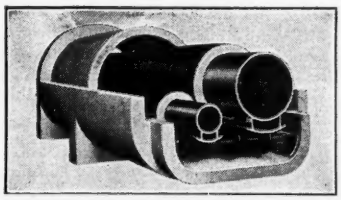


joints with long close fits—no running seals. A fan mounted outside this shell forces a blast of air between the inner shell and the outer one thereby providing effective cooling.

These motors are made in all sizes from 1 to 200 hp. as squirrel cage induction motors to meet all classifications of torque and inrush requirements and with 1, 2, 3 or 4 speeds. They are available also as across-the-line-start motors up to 200 hp. and can be supplied for power factor correction as 100 or 80 per cent leading power factor induction motors in all sizes.

Precast Concrete Conduit

FOR UNDERGROUND PIPE Lines the Underground Steam Construction Co., 75 Pitts St., Boston, Mass., has developed a precast concrete conduit designed for high strength, capacity, efficiency and economy. Because of the shape, this conduit has approximately 12 per cent greater capacity at the bottom than circular conduit, giving additional space for drainage, pipe rolls and supports. The conduit is made in



two sections, top and bottom. No special sections are required for pipe support, which are easily and quickly installed, firmly and permanently anywhere through the conduit. Conduit will be manufactured in the locality in which it is to be installed from local material and with local labor, thereby saving high transportation cost and damage in transit.

Two New Tool Cutters

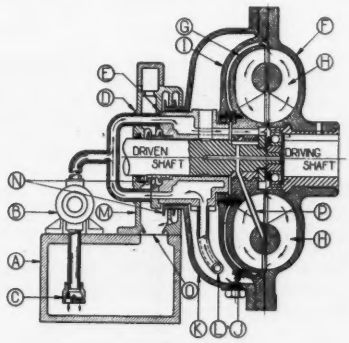
THE BORDEN CO., Warren, Ohio, announces two additions to their line of pipe tools. The No. 100 Beaver Tubing Cutter for thin wall tubing and the No. 204 Square-built wheel cutter.

The No. 100 is a handy little

wheel cutter for copper tubing ⅛ to ¾ in. sizes. It produces clean, square ends, without crushing and has a renewable blade-reamer. The No. 204, in 2½ to 4 in. sizes, have frames built to establish true parallel working surfaces as the foundation to subsequent machining operations.

Hydraulic Coupling

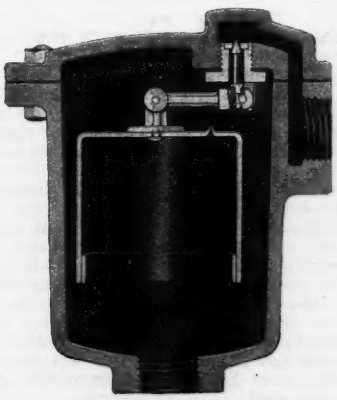
NEWLY DEVELOPED hydraulic coupling, making possible variable speed control with a constant speed driver, has been perfected for use with centrifugal pumps and was introduced at the recent conference of American Blower Corp. sales engineers in Detroit, Mich. Engineers say that it is designed for use with



a simple induction motor to replace the slip ring motor in pump operation and will eliminate the loss of power incurred where throttle valves are used. Because of the infinite number of speeds possible with this coupling, the exact speed for any desired load may be obtained readily and without loss of power.

New Marsh Steam Trap

MARSH No. 500 inverted bucket steam Trap for installation on all classes of hospital and kitchen



equipment is announced by the Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill. The motive element is an inverted seamless open bucket operating through a cast brass lever arm to open and close the swivel valve pin. Body and cover are of cast iron. Bucket is of seamless copper and levers and clevises are of cast bronze. Pins, valve and seat are stainless steel. All piping connections are made to the body, which permits removal of the trap cover without disturbing piping. This trap, suitable for working pressures up to 125 lb. per sq. in. is made in three sizes, ½, ¾ and 1 in.

News from Washington

THE FEDERAL POWER COMMISSION has been called upon to consider the problem of determining the amount which one hydroelectric power company owes to another, on account of benefits resulting from the latter company's upper reservoirs, provided for the storage of the waters of the stream flow feeding both projects. In fact any regulation of the headwaters through the construction of head-water improvements, that results advantageously to the lower plant or plants is subject to a tax allocated from the lower plant to the plant providing the improvements out of its own construction.

The case which brings this matter to the consideration of the Federal Power Commission for the first time, since the enactment of the power law in 1920, is that which involves the San Joaquin Light and Power Corp. and the Southern California Edison Co., Ltd. The former is a subsidiary of the Pacific Gas and Electric Company. The law has a provision enabling the Commission, to hear the case and establish the amount to be paid, this amount to be paid being an equitable share of the annual fixed charges on the improvements, and charged to the benefited company.

In 1920, the San Joaquin Light and Power Corp. completed a hydroelectric power development on the San Joaquin River in California and known as the Kerckhoff project. Higher up the river and its tributaries, the Southern California Edison Co., during the period from 1911 to 1928 constructed water storage reservoirs and incidental works. These, and especially the Shower Lakes, Florence and Huntington reservoirs, are alleged to be of substantial benefit to the San Joaquin company, by holding back the flood waters, so as to provide a continual water supply available for generating electricity at all times, and particularly during periods when there would otherwise be insufficient water.

News From the Field

On November 8, 9, 10 and 11, the National Association of Practical Refrigerating Engineers will hold their 24th Annual Convention and Exhibition at the Roosevelt Hotel, New Orleans, La. The following week the National Association of Ice Industries will hold their Annual Convention at the same hotel.

George B. Karelitz has resigned from the position of manager of the marine engineering division of the Westinghouse Electric and Manufacturing Company, South Philadelphia Works, to accept the position of Professor of Mechanical Engineering in Columbia University. Mr. Karelitz intends also to engage in consulting practice in order to maintain close contacts with industry.

The Johnson Corp., Three Rivers, Mich., announces acquisition of the Gast line of air separators, aftercoolers and oil absorbers. R. O. Monroe has become associated with the organization as manager of sales. L. D. Goff is president and general manager of the Johnson Corp.

The General Electric Co. and four of its associated companies have announced the removal of their offices in New York City to the new General Electric Building, 570 Lexington Avenue at 51 St. The change affects the executive offices, New York district office, air conditioning department, electric refrigeration department, Atlantic division of the incandescent lamp department, merchandise department, and plastic department of the General Electric Co., and the General Electric Contracts Corp., G. E. Employees Securities Corp., General Electric Realty Corp., and International General Electric Co., Inc. New York City headquarters were formerly at 120 Broadway, where for 15 yr. three complete floors were occupied. Approximately 50 per cent of the new building is occupied by the company.

Chicago Pneumatic Tool Co. announces the opening of a new branch office at 1028 Sixth Avenue South, Seattle, Wash., A. M. Andresen, Manager. A representative line of the company's products will be carried in stock, as well as parts for servicing.

The Smoot Engineering Corporation, manufacturers of Smoot Control, have moved their general offices and factory to Summit, New Jersey, where they have set up complete engineering and manufacturing facilities for their apparatus. Their former address at 136 Liberty Street, New York City, is still maintained as a sales office with H. R. Kessler in charge. A Pittsburgh sales office under the direction of Colonel C. L. Joly has been opened at 405 Bessemer Building and a Chicago sales office will be opened soon.

The Allen-Sherman-Hoff Co. has announced that it is now represented in Chicago territory by the Diamond Power Specialty Corp., 20 North Wacker Drive, Chicago, Ill.

Gordon Fox, who has been associated with the Leningrad staff of Freyn Engineering Co., has returned to the United States and will resume his connection with the American activities of this company. Mr. Fox has devoted the last 5 yr. to engineering work in the Soviet Union for Freyn Engineering Co., during which time this company, in association with the Russian organization, Gipromez, has supervised the development of the steel industry of the Soviet Union. Mr. Fox was identified with the power and electrical phases of this work.

National Board of Boiler and Pressure Vessel Inspectors will hold their Ninth Annual Convention at the Hotel McAlpin, New York City, on October 17, 18 and 19. An extensive program of technical and administrative subjects has been prepared on subjects of particular interest to the members. Among the speakers will be Dr. D. S. Jacobus, Chairman of the A.S.M.E. Boiler Code Committee; Charles E. Tudor, President of the American Boiler Manufacturers Association; and James A. Beha, General Manager and Counsel of the National Bureau of Casualty and Surety Underwriters. Two sessions will be held daily, there will be a luncheon each day at the hotel, with a dinner on Tuesday evening at which L. C. Peal will be toastmaster. On Thursday afternoon there will be the election of officers.

For the Engineer's Library

Conduction of Electricity in Gases. By Joseph Slepian. 188 pages, illustrated by sketches. Size 8½ by 11 in. Cloth. Published by the Educational Department of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. Price, $4.00.

Few developments in electrical engineering has revealed more conclusively the need for fundamental knowledge of physical principles than the development of the modern high capacity circuit breaker. In this field, that is in the application of fundamental knowledge of physics to the practical design of high capacity circuit-breakers, nobody has been a greater force than Dr. Joseph Slepian of the Westinghouse Electric and Manufacturing Co. His knowledge and researches into the theory of the electric arc, its structure and its mechanism have given to the electrical industry a new foundation on which to develop apparatus.

Because of Dr. Slepian's keen analytical knowledge of arc phenomena, this new book forms a valuable addition to electrical literature. Essentially an authoritative book for researchers, physicists, professors and students on the passage of electricity through gases, this book is perhaps the most concise and advanced treatise available on the subject which stresses the bearing of the theory upon applications in electrical engineering. Theory and illustrative examples are up to the minute, the text being notes taken by students in a series of lectures given by Dr. Slepian for a selected group of research workers and engineers. Sketches and mathematics are freely used.

The first thirty pages of the book stress the fundamentals of electrical conduction in gases, while the remaining pages apply these basic considerations to the study of such discharges as glows, arcs, sparks and corona, as they are presented to the electrical engineer in the normal and abnormal operations of his apparatus. The fundamental phenomena of low current discharges, such as cathode rays, photoelectric effect, thermionics, etc., are treated briefly but sufficiently to form the basis in developing the theory of heavy current discharges.

Starting with the atomic theory of matter, those chapters of the kinetic theory of gases which are necessary for the proper understanding of the theory of electric conduction in gases are developed in an elementary manner, from ordinary mechanical principles. The ideas of classical mechanics and electromagnetism are used throughout, although frequently the inadequacy of these ideas for complete description of atomic processes is pointed out, and places where quantum mechanics is needed are indicated, although quantum theory itself is not developed.

The nine divisions under kinetic theory range from a discussion of "Pressure Effect of a Gas," to "Evaporation of Electrons from Metals." The other thirty-two divisions of the book, dealing with electrical properties of gases, include "Coefficient of Recombination," "Ionization by Collision," "A-C Switching," "Glow Discharge in the Vacuum Switch," "Backfires in Mercury Arc Rectifiers," "Dynamic Characteristics of Arcs," etc.

The author needs no introduction to physicists and engineers in America or abroad. In addition to his contributions to the advancement of the electrical art as a consulting research engineer in the Westinghouse Electric & Manufacturing Company, he has extended his influence, particularly with the rising generation of research workers, engineers and educators.

Sparks from the Electrode by C. L. Mantell. First edition, Cloth 5x7¼ in. 128 pages, illustrated. Published by The Williams and Wilkins Co., Baltimore, Md., 1933. Price $1.00.

The direct benefits derived from the use of electricity are obvious to everybody, but comparatively few know much about the indirect benefits—those accruing from our use of the power of electricity, those made possible by the science of electrochemistry for example. This little volume which is another of the popular Century of Progress Series, describes the growth of the electrochemical industries with the advent of cheap power. It forms an extremely interesting story, one that everyone will find interesting, for few realize what a far reaching effect the progress in the electrochemical industries has had on our lines. Mr. Mantell discusses the electrolytic refining of metals and electroplating. He tells how we make substances harder than nature can make them and how we prevent corrosion. There in 127 pages are the highlights of one of the most fascinating industries of any century.

"Twenty-one Years" is the title of an attractively printed and illustrated 60-page book recently issued by the British Electrical and Allied Manufacturers Association. This is a review of the progress and achievements of the "Beama," as the association is referred to. It is the record of an industry which is today one of the world's three largest exporters of electrical goods. Members of the B. E. A. M. A. manufacture 97 per cent of the total value of electrical machinery and apparatus produced in Great Britain. The book through its excellent illustrations gives an excellent idea of the range and character of electrical goods manufactured in Great Britain.

CHEMISTRY TRIUMPHANT, by William J. Hale. First Edition. Cloth 5x7¼ in., illustrated, 152 pages. Published by The Williams and Wilkins Co., Baltimore, Md., 1932. Price $1.00.

This little book belongs to that very interesting series known as the Century of Progress Series of dollar books. The purpose of these books is to place the message of the Century of Progress Exposition in convenient form for ready assimilation—each title selected from the viewpoints of authenticity and readibility and written by specialists who are authorities in their respective fields. Two of these books, Our Mineral Civilization and The New Necessity, were reviewed in our June issue.

In this book Mr. Hale discusses the achievements and future possibilities of modern chemistry, and he is well qualified to do this, for he is director of Organic Chemical Research at the Dow Chemical Co. He presents the subject from a broad viewpoint and indicates its economic and political aspects as well as its technical aspects. Only now he contends, are we beginning to have a true insight into what chemistry means in human affairs. He presents a view of human history in chemical perspective, views present and economic problems through chemical glasses and at the end elucidates the fine principles of "chemecorromics."

PRELIMINARY reports of the Oil Engine Power Cost Committee, Oil and Gas Division of the A.S.M.E. are now available at the headquarters of the society, 29 West 30th St., New York City. Cost is 90 cents per individual copy or 75 cents in quantities of 10 or more. This year's report, covering the year 1932, consists of 32 pages of tabulated and plotted data covering 140 plants and 377 engines. This is a considerable increase over the 1931 report which covered but 119 plants and 330 engines.

LOSS OF HEAD in Cast-Iron Tees is the title of Bulletin No. 41 published by the Engineering Experiment Station, Agricultural and Mechanical College, College Station, Texas. This is the report of an investigation covering 1 and 1½-in. cast-iron tees, all of the tests being run at a water temperature of 70 deg. F. Complete curves and data are given, conclusions being that the loss of head in cast-iron tees is a function of the per cent of water diverted at right angles in the tees, in most cases the loss of head for the portion of water flowing straight through the tee may be neglected.

EFFECT OF VARYING Compression Ratio and Inlet Temperature on Engine Performance is the subject of Bulletin No. 50 published by the Engineering Experiment Station, Michigan State College, E. Lansing, Mich. This bulletin gives the results of tests conducted on a Christie variable compression test engine, 3 1/16 in. bore and 4½ in. stroke. Test results show that the mean effective pressure, fuel economy and volumetric efficiency increase with the compression ratio; the mean effective pressure increases with the spark advance up to the point of detonation, which is the most severe when operating with an air fuel ratio and with a spark setting that would give maximum power if no detonation occurred; the spark setting and carburetor setting must be adjusted for each fuel to give best results. The price of this 13-page paper bound bulletin is 25c.

STEEL-CASED boiler settings are described in a new 8 page bulletin recently published by the Plibrico Jointless Firebrick Co., 1800 Kingsbury St., Chicago, Ill.

USE OF CARBEX silicon-carbide superrefractories for the purpose of lining water-gas generator furnaces is described in a new 4 page bulletin published by McLeod & Henry Co., Troy, N. Y.

JAS. P. MARSH CORP., 2073 Southport Ave., Chicago, Ill., has just issued its new catalog No. 68, describing the complete Marsh line of gages, instruments and heating equipment. This catalog is unusually comprehensive and contains much interesting engineering information regarding the design and operating features of the various devices. It includes numerous illustrations and line diagrams.

AN EXCELLENT SOURCE of information on valves and valve layout is the new catalog No. 23 just published by Jenkins Bros., 80 White Street, New York. Not only does this book cover 400 Jenkins Valves, in a wide range of types and patterns, but also it gives unusually complete details. All features of design and construction are clearly and fully described. Full information is given about the metals used in making the valves. Services, pressure, temperatures and fluids for which the valves are recommended are stated. In fact, this catalog gives all of the facts that a valve buyer wants in selecting and specifying valves.

The last section of the book contains many pages of engineering data that is constantly needed where valves are used.

COLUMBIA ELECTRIC MFG. CO., 1292 East 53rd Street, Cleveland, Ohio, has issued a bulletin, MS—1, describing its new line of D.C. and A.C. switchboard instruments and switchboard panels. Type E—45 instruments (5" across front flange) are suitable for the highest type of switchboard work, and those of Type S—30 (2⅝" across flange) for use where smaller and lower-cost meters are desired. Four standardized types of panels, to meet average requirements, are described; special designs being supplied to order.

A BULLETIN RECENTLY issued by Columbia Electric Mfg. Co., 1292 East 53rd St., Cleveland, Ohio, describes the company's manufacturing and repair service for all types and sizes of commutators and slip-rings. It includes both the re-filling of existing shells and the manufacture of complete new assemblies.

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, devotes its Bulletin No. 569 to belt idlers, describing the company's idler which is designed for universal application. The bulletin lays particular emphasis on the use of the idler for conveyor belts and accompanies the description with drawings and insulation photographs.

LEE B. METTLER CO. of Los Angeles, Calif., has issued a catalog describing the Mettler Entrained Combustion Gas Burner, giving the burner specifications, installation drawing and combustion engineering data, helpful to engineers wishing to install this type of burner.

NICHOLSON CONTROLLING VALVES are described in Bulletin No. 933 recently issued by W. H. Nicholson & Co., Wilkes-Barre, Pa. The bulletin deals with the application of these valves for air, steam, oil, tar and water service.

LINK-BELT CO., Chicago, has just completed a 128-page Data Book No. 1289 on its Caldwell Helicoid and Sectional-Flight Screw Conveyor. The book is copiously illustrated, contains engineering data and list prices, and is a comprehensive treatise on the subject.

FRICK CO., Waynesboro, Pa., have recently published Bulletin No. 180-A, entitled "Refrigeration for Breweries" describing and illustrating the use of Frick equipment and showing its place in the modern brewery.

MOTORCOMPRESSOR, a new 2-stage, air cooled air compressor with built-in motor is described in a bulletin recently published by Ingersoll-Rand Co., 11 Broadway, New York City. Machines for 100 lb. discharge pressure have a piston displacements range from 113 to 310 c.f.m.

FABRICATION of Ox-welded Piping is the title of a 6 by 9 in., 152 pp. paper bound booklet published by the Linde Air Products Co., 205 East 42nd St., New York City. The book is well illustrated, gives step-by-step procedure for oxy-acetylene welding of steel, cast iron, copper, brass, etc., and for making fittings. Testing and qualifying welders for pipe work, inspection methods and estimating costs are also covered in other chapters. The book is sent free to those interested in welding and welding processes.

MASON-NEILAN REGULATOR CO., 1190 Adams Street, Boston, Mass., has just published an illustrated, 24-page bulletin, No. 2000-c, describing in detail the construction and operation of their line of compensated pressure control instruments. The Mason-Neilan Control Valve Compensator with which every pressure controller is equipped is fully explained. It is claimed that this proven development insures precise pressure control by eliminating "hunting", "cycling" and overcontrol. It also carries an explanation of many other characteristic features of these instruments as well as the Parabolic Gradual Opening Ball Bearing Control Valves.

Mason-Neilan Compensated Recording Pressure Controllers, non-recording controllers and recording pressure gages are all described in detail in this new bulletin which can be had upon request.

STANDARD FUEL ENGINEERING CO., Detroit, Mich., announces in a six-page folder that all its high temperature cements, dry and plastics, will be marketed under the trade name Zero. The folder contains a complete description of each product, also general information of a technical nature on where and how to use these refractory products.

GOULDS PUMPS, Inc., Seneca Falls, N. Y., in its Bulletin No. 204 describes a close-coupled Motor-Centrifugal pumping unit which has recently been developed. These pumps are built in sizes from ¾ to 4 in., for capacities up to 1000 g.p.m. and head ranges from 10 to 250 ft.

Ingersoll-Rand Company, 11 Broadway, New York City, has issued an illustrated 10 p. bulletin, Steam Jet Refrigeration Units. The booklet discusses the theory and practice of water-vapor refrigeration, the importance of correct steam-jet design, the operating characteristics of steam-jet boosters and the steam and water requirements of this type of apparatus.

Power Plant Construction News

Calif., Oakland—East Bay Municipal Utility District, 512 Sixteenth Street, is planning financing in amount of $8,409,000 for extensions and improvements in electrical properties, including construction of new hydroelectric power plant on Upper Mokelumne River, and new steam-electric standby power station at Oakland, extensions in transmission lines, power substations and other structures. Engineering department is in charge.

Calif., San Diego—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured appropriation of $160,000, for a steam power plant for central heating service at San Diego Navy Yard, and plans early call for bids.

Calif., San Francisco — Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured appropriation of $150,000, for extensions and improvements in power plant at Mare Island Navy Yard. Early call for bids planned.

Calif., Selma—Board of City Trustees has authorized financing in amount of $57,300 for construction of new municipal electric light and power plant, using Diesel engine-generator units. Also, fund of $106,000 for extensions and improvements in municipal water system, including four new pumping plants, elevated steel tank of 300,000-gal. capacity, on 120-ft. tower, and other mechanical equipment. Edward K. Hussey, Syndicate Building, Oakland, Calif., is consulting engineer.

Del., Wilmington—New Jersey-Delaware Brewing Co., Fifth and Adams Streets, recently organized, plans installation of electric power equipment, pumps, conveyors and other mechanical equipment for extensions and improvements in former plant of Joseph Stoeckle Brewing Co., location noted, lately purchased. Entire program will cost about $100,000.

D. C., Anacostia—Board of District Commissioners, District Building, Washington, D. C., has secured appropriation of $231,000, for new pumping and interceptor station for municipal sewage system at Anacostia. Early call for bids planned.

D. C., Washington—Indian Service, Department of the Interior, has secured fund of $57,000, for new power plant at Indian Reservation, Northern Navajo district, N. M., and plans early call for bids.

D. C., Washington—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured fund of $325,000, for extensions and improvements in power plant at local navy yard, and proposes early call for bids. Also, appropriation of $230,000 for extensions and improvements in fuel oil system at Pearl Harbor Navy Yard, Honolulu, T. H.

Fla., Miami—City Ice & Fuel Co., 630 N. W. Fourteenth Street, has filed plans for one-story addition to steam power plant. Cost about $20,000, with equipment.

Fla., Pensacola—Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids until October 11, for steam power plant for central heating system at naval air station, Corry Field, Pensacola, including watertube and firebox boilers, air atomizing oil burners, motor and turbine-driven air blowers, fuel oil pumping and heating equipment, boiler feed pumps, sump pumps, motor and turbine-driven induced draft fans, oil storage tanks, feed water heater and complete accessories, as per Specifications 7405.

Md., Annapolis—Bureau of Yards and Docks, Navy Department, Washington, D. C., has been granted appropriation of $575,000 for extensions and improvements in power plant at Naval Academy, Annapolis. Plans early call for bids.

Mich., Ironwood — Board of City Commissioners has preliminary plans for a municipal electric light and power plant, estimated to cost about $900,000, and will arrange financing in that amount at early date.

Mich., Menominee—At special election, citizens have authorized City Council to arrange bond issue of $650,000 for a municipal electric light and power plant. Plans will soon be drawn. T. R. Hasley is city engineer.

Mo., California—Common Council has preliminary plans under way for a municipal electric light and power plant, to cost about $145,000, and will arrange financing in that amount at early date. W. B. Rollins Co., Railway Exchange Building, Kansas City, Mo., is consulting engineer.

Miss., Ellisville—Common Council is considering a proposal tendered by Ellisville Ice Co., Ellisville, to construct and operate an electric light and power plant for commercial service.

Neb., Gering—Common Council is arranging financing for $65,000, for new municipal electric light and power plant, using Diesel engine-generating units. Early construction planned.

N. H., Portsmouth—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured appropriation of $100,000 for extensions and improvements in power plant at Portsmouth Navy Yard, and plans early call for bids.

N. D., Minot—City Council is planning construction of a municipal electric light and power plant to cost $950,000, with distributing line, and proposes bond issue in that amount at early date.

N. D., Wahpeton — Indian Service, Department of Interior, Washington, D. C., has secured fund of $35,000, for steam power plant for central heating service at institution at Wahpeton, and plans early call for bids. (F. P. 99).

Ohio, Cincinnati—Andrew Juergens Co., Spring Grove Avenue and Alfred Street, has plans under way for new power plant unit for service at soap factory, reported to cost close to $40,000, with equipment. A. M. Kinney, Inc., Carew Tower Building, City, is consulting engineer.

Ohio, Dover—Department of Public Service, C. H. Krantz, director, plans extensions and improvements in municipal electric light and power plant, including installation of new steam turbine and auxiliary equipment. A fund of about $105,000 is being arranged for work. Waldo Hartline is city engineer.

Okla., Wheelock — Indian Service, Department of Interior, Washington, D. C., has secured appropriation of $35,000, for new steam power plant at institution at Wheelock, for central heating service; also appropriation of $26,000, for water supply system, including pumping machinery, etc., for institution in Choctaw-Chickasaw district. Early call for bids planned.

Pa., Fort Mifflin—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured fund of $65,000, for extensions and improvements in steam power plant for heating service at Fort Mifflin, and plans early call for bids.

Pa., Reading—City Council will soon arrange special election to approve bond issue of $1,850,000 for extensions and improvements in municipal water system, including installation of pumping machinery and auxiliary mechanical equipment, pipe lines, increase in storage reservoirs, etc. City engineering department will be in charge.

S. D., Pine Ridge—Indian Service, Department of Interior, Washington, D. C., has fund of $38,000, for new steam power plant for central heating service at Pine Ridge, and proposes early call for bids.

Tenn., Knoxville—Municipal Power Committee, W. A. Cockrum, chairman, is considering plans for construction of a municipal electric light and power distributing system for commercial service throughout the city, with power substations and auxiliary structures. Entire program is estimated to cost $4,367,000, and financing in that amount will be arranged. Proposition will be placed before voters at forthcoming general election. It is proposed to secure power at wholesale from new hydroelectric generating plant on Clinch River, about 20 miles from city, to be constructed by Tennessee Valley Authority, as part of Federal Muscle Shoals power project.

Texas, Marble Falls — Common Council plans installation of pumping machinery and auxiliary mechanical equipment for new municipal water system. Fund of $43,500 is being arranged for complete project. H. R. F. Helland, Frost National Bank Building, San Antonio, Texas, is consulting engineer.

Wash., Bremerton—Bureau of Yards and Docks, Navy Department, Washington, D. C., has secured appropriation of $50,000, for new gas plant at Puget Sound Navy Yard, and plans early call for bids, also, fund of $55,000, for new distributing and service lines, and appropriation of $1,350,000, for new electric shop and machine works, same yard.

W. Va., McMechen—Common Council plans installation of pumping machinery and other mechanical equipment for extensions and improvements in municipal water system. Entire project will cost about $85,000. Surveys are being made.

Wis., Seymour—Common Council is considering installation of pumping machinery and other mechanical equipment for extensions and improvements in municipal water system. Entire project will cost about $90,000. A. E. McMahon Engineering Co., Menasha, Wis., is consulting engineer.